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THE ENGINEERS' DIGEST

REVIEW OF ENGINEERING PROGRESS ABROAD

PRINCIPAL CONTENTS

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A Bomb-Proof Stand-by Steam Power Plant of the Town Berne.

Automatic Recording of the Angle of Deflection of Control Surfaces.

The Relation between Octane and Cetene Numbers.

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PREFACE

The large number of appreciative letters, coupled with the ever increasing reader-support indicate the approval with which the Engineering Industry has welcomed THE ENGINEERS' DIGEST.

We are grateful for this support, and most especially for such constructive criticism as has helped us to make the journal more useful in many respects.

In our last issue, a classification of Contents, according to the main branches of Engineering, was introduced. At the suggestion of a number of libraries, reference-dates have also been added to facilitate card-indexing.

At the suggestion of many readers, we have decided as a matter of editorial policy, to retain the Metric system whenever it has been used in the original article.

The advantages of the purely decimal metric system are self-evident. They have been stressed recently by Major Oliver Stewart, who pointed out in his paper, "Aeronautics," how the co-operation of the Armee de l'Air was hindered by the different measuring systems used. "The Aeroplane" (Sept. 6th, 1940) gave another instance of how this point hampers our efforts: "The Packard Company which took on the order for 9,000 Merlins is expected to have some difficulty with them because they are designed on metric measurements and these will be changed over to the inch system."

We are fully aware of the immense investment in machine tools, gauges, calipers, etc., which would be necessary before the English speaking world could standardise on the metric system, but we believe this outlay would be fully recuperated by time-savings in all operations. A change to the metric system would also bring us immense advantages in the export market.

We invite any further suggestions for the improvement of this journal, and will give these the most careful consideration.

This issue has been delayed for reasons outside our control. We trust our readers will understand and excuse the delay.

THE EDITOR.

NEW GERMAN MACHINE TOOLS

(From *Die Werkzeugmaschine*, Berlin, Vol. 44, No. 5, March, 1940, pp. 87-118).

THIS article describes the latest developments of German Machine Tools since the last Leipzig Fair.

Lathes.

Fig. 1 shows a heavy duty lathe with stepless speed regulation. The largest speed range of 1:64 is obtained by the use of a P.I.V. chain-drive, which is built into the head stock and runs in oil. The feed box has forty steps and practically all kinds of threads, e.g. metric, Whitworth, modul, etc., can be cut. The left hand base of the head stock encloses the motor, which is mounted on a balanced frame and drives the head stock by a V belt. The entire drive is built-in. The rigid design of the machine excludes vibration even at high speeds.

An adjustable stop is provided for the longitudinal feed, which is limited automatically by means of a slipping coupling in the apron. An automatic pump provides the appropriate lubrication of the various bearings, gears, slides. The spindle runs in precision roller bearings. The front bearing is adjustable. The precision ball bearings fitted in the front neck take the axial thrust. A hand wheel on the head stock serves as a speed regulator for smaller units. Larger machines have for this purpose a small regulation motor, controlled by a hand wheel on the saddle.

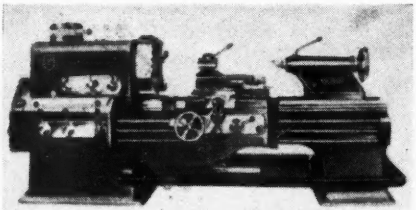


Fig. 1

Fig. 2 gives a view in the inside of the head stock of a new type of NS lathe, manufactured by the German Niles works. The motor is flange mounted on the foot of the head stock and drives through sliding change gears and a V belt. The pulley can rotate independently from the spindle on ball bearings. At high speeds the pulley engages with the centre wheel through a dog coupling. At lower speeds a transmission shaft turns the centre wheel. With this arrangement an exceptionally smooth and vibrationless running of the machine is achieved.

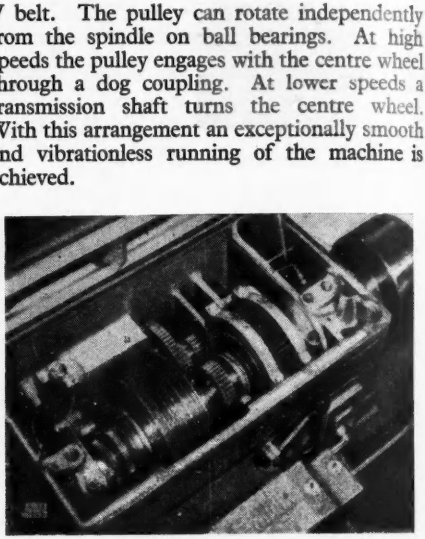


Fig. 2

The Magdeburg DBO machine is shown in Fig. 3. A very simple design and the elimination of all unnecessary parts is the main

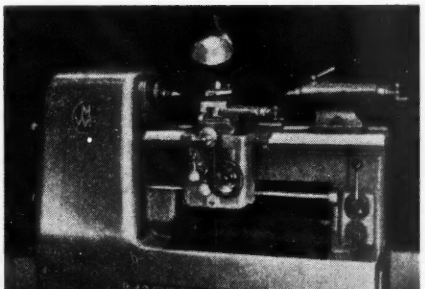


Fig. 3

characteristic of this lathe. The head stock and the body are cast in one piece. This is responsible for the great rigidity and the simple design of the machine. The guides of the lathe slide are double prismatique and are ground very carefully. The end plate of the casing on the left hand side forms a door. The motor is in the base and can be lifted and tilted in order to make the changing of the belt easier. To obtain a smooth running, the spindle is driven by a belt and no toothed gearing is employed.

Fig. 4 shows an improved turret lathe. The gear box is elastically coupled to the prime mover, and forms a separate unit in the bottom of the casing. It is placed on three rubber studs to avoid vibration. The driving power is transmitted to the mandrel stock either by means of a V belt or by a gear wheel arrangement. Velocity ratios up to 1:8 can be obtained in the latter case by the use of a synchronised

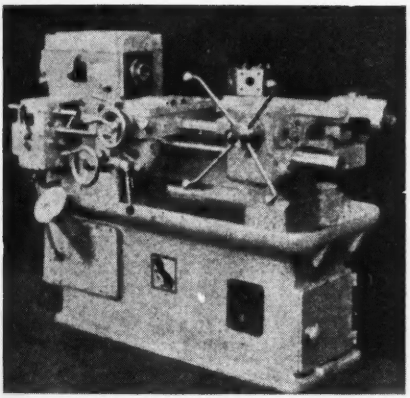


Fig. 4

toothed clutch. The velocity ratio of the motor and the spindle can be changed by a hand wheel, when the motor is switched off. A safety switch prevents the changing of the gear while the motor is still running.

Fig. 5 shows a universal backing of lathe. This machine can produce all kinds of milling cutters backed for clearance and cutting tools with left or right hand threads. The relieving apparatus can be disconnected, and hence, the machine can be used as an ordinary lathe as well. A relief grinding apparatus corrects

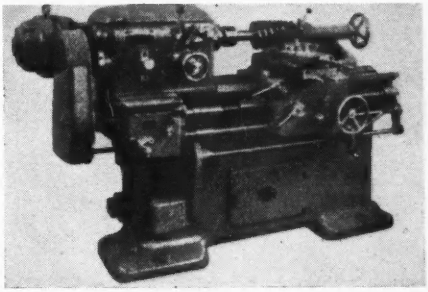


Fig. 5

faults in the pitch and changes in the profile of the teeth, and thus a high degree of accuracy of the pitch and the profiles is obtained.

Fig. 6 shows a very large boring and turning mill. This is claimed as the largest machine tool in the world. The approximate weight of the machine is 1,850,000 kg. The greatest diameter when the side arms are in their forward position is 19m., when in the backward position, 25 m. The face plate is built up from two parts : an inner plate of 8750 mm. dia., and an outer ring plate of 18,500 mm. dia. It is stated that there is room on the face plates for 1,600 men. Smaller work pieces are rotated on the inner plate only, while larger pieces are rotated on the two plates coupled together. Ring shaped work pieces are rotated on the outer plate, while the inner face plate is not rotating. The greatest working height above the face plate level is 6000 mm. Both the saddles are inclinable. The left hand one has a slotting apparatus with a ram to carry

Fig. 6

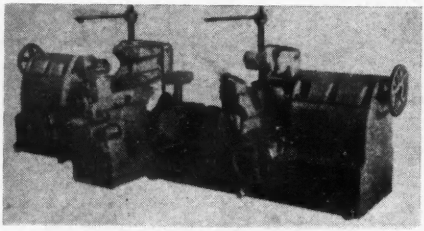


Fig. 7

the slotting tool. The cross slide is fixed in position by two electric motors. Push button stations are provided to control the main motor, the saddles, etc. Ammeters, revolution counters and other instruments are also provided. The prime mover consists of two D.C. motors each of 200 H.P. output. Separate motors operate the saddles, cross slide and oil pumps.

Fig. 7 shows a new type of axle turning and burnishing machine. The box shaped main bed is cast in one piece with the head stock. The top slides of the machine carry

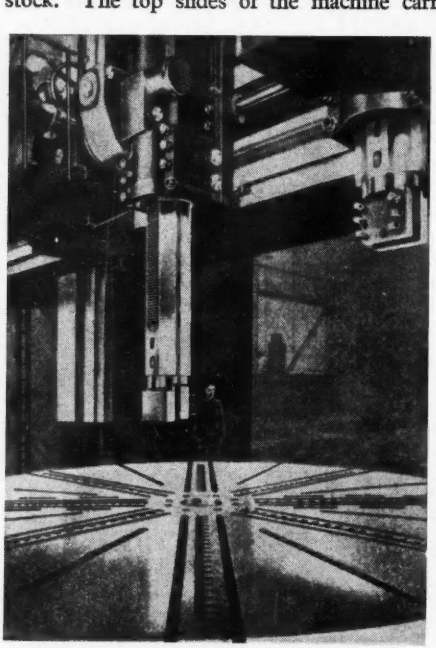


Fig. 8

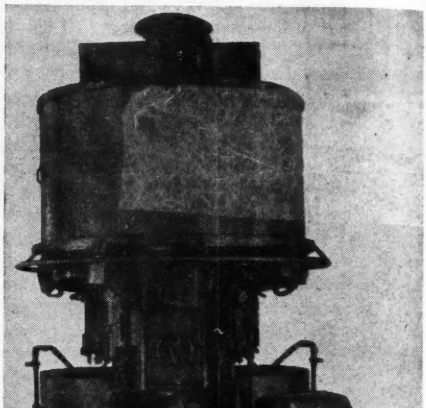


Fig. 9

the turning and burnishing tools. The burnishing rollers run on roller bearings and are carried by two levers. The polishing pressure is adjustable. The burnishing of the radii is facilitated by a friction clutch. An axial pressure is applied to the rollers during the advanced motion. The machine is controlled from an operating station in the front of the bed. The automatic advances of the burnishing and turning tools can be separately adjusted at the two saddles.

A turning and boring mill for 6000 mm. dia. is shown in Fig. 8. The cross slide and its connection to the side arms are rather unusual. The cross slide is fixed to the guides by clamps on the front side of the arms, and also at the back of the inner surfaces of the arms to give an increased rigidity and reduce vibration. The cross slide forms a closed rectangle with the arm and is clamped to it by an electro magnetic device. The latter is controlled by press buttons from the control platform. The motors for moving the cross slide

are fixed on the top of the slide. A safety device prevents the starting of these motors while the magnetic force is holding the cross girder fixed to the stands.

The vertical automatic lathe " VA 630 " is shown in Fig. 9. The machine is a six-spindle automatic turning lathe for chuck jobs. The six units are arranged vertically around the centre column. The spindle rotates in a circle, and each position represents a different working phase. (1) is the initial or loading stage. In this position the spindle does not rotate. It passes then to position (2-6), and finally comes to position (1) again, where the finished work piece is taken out. The machine is hydraulically operated and this accounts for the following advantages :

(1) Accurate holding of the work piece. The advance for each sliding part is stepless and independent. The speed range of the spindle is very high.

(2) Quick changing of the work pieces. Simple device for adjusting the length of the feed.

(3) Working safety. No faulty coupling or changing of the gears can occur due to the co-operation of the electric and hydraulic mechanism.

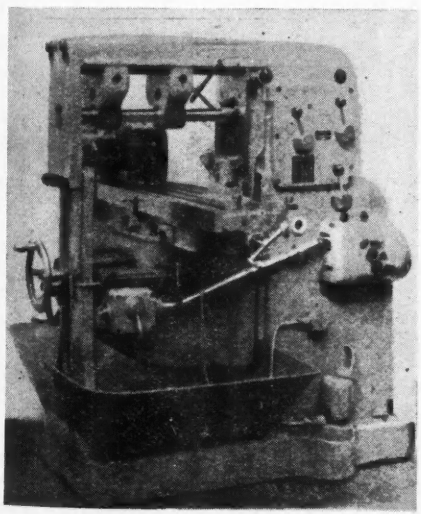


Fig. 10

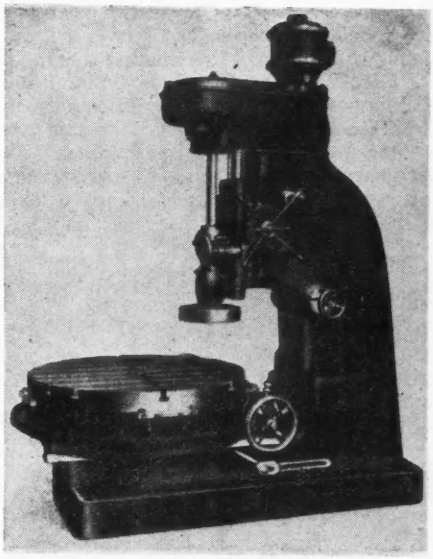


Fig. 11

Milling machines.

Fig. 10 shows a horizontal milling machine manufactured by the Krebs work. The motor is inside the enlarged base. The milling spindle has 12 speeds. It runs in oil, and is driven by a V belt. The operating wheels and levers are grouped ogether. The speed of the spindle is indicated on coloured plates, by the

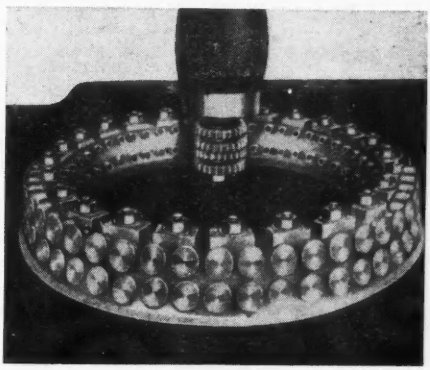


Fig. 12

position of the levers. The toothed gearing for the spindle and for the feed gear is a simple sliding change gear. Vibrationless running of the spindle is obtained by using a conical front bearing bush. A small oil tank is cast on the top of the bearing bush and an adjustable valve controls the lubricating oil consumption. The stay bearings and the main bearings are automatically lubricated by an oil pump. Bracing of the frames is necessary for larger units.

Fig. 13

Fig. 11 gives a side view of a vertical rotary milling machine manufactured by Messrs. Müller & Montag. The machines are produced in three sizes and are speeded for milling either steel or light metals. The machine is very suitable for milling uniform surfaces, slots, circular and arch shaped pieces. It can be also used for cutting large holes in index plates. Frame shaped work pieces like filter presses or printing machine parts can be very easily machined on it. The machine is mainly used for continuous milling of series produced pieces. For this purpose a jig (Fig. 12) is to be used, of suitable shape for the work piece. The changing of finished pieces to new ones takes place opposite to the spindle while the machine is working. The height of the edge of the machine table from the ground level is constant, since the table cannot be moved in the vertical direction.

Fig. 13 shows a milling machine especially designed for milling of dies and links. The column can slide along a slot at the rear of the bed to follow the radius of the link. If the longitudinal power traverse of the table is engaged, then the table is forced by the grinding gear to perform a diagonal movement. The adjustment of the link radius is brought about by the hand wheel shown in Fig. 13 at the back of the machine. When the radius of the link is adjusted on the grinding gear, the radius of the cutter must also be taken into account. A flanged motor serves as a prime mover. The bearing bush for the spindle bearings is conical at the bottom and cylindrical at the top. The bearing bushes are adjustable. The axial pressure is taken up by a roller bearing. Automatic sliding of the milling carriage can be arranged. An automatic mechanism for advancing the milling carriage is also provided.

A vertical milling machine for cutting channels into slide valves is shown in Fig. 14. The romboid, rectangular or triangular shape of the slide valve channels require a specially designed machine which has a variable combination of longitudinal and circular feed as well as a cross adjustability of the work table. The machine can be adjusted for the following purposes:

(1) A large number of similar slide valves can be milled using a pattern.

(2) Individual slide valves can be milled according to a prepared form.

(3) A special mechanism enables the milling of identical channels without using patterns or forms.

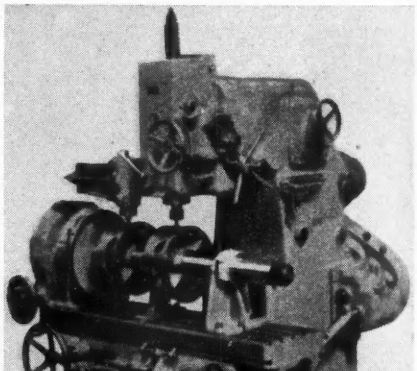


Fig. 14

The principle of operation is as follows : a hole is drilled first in the work piece and the cutter is introduced to it. Then the required shape can be milled in the work piece. Movements in three directions are available for automatic machining. During a simple rotation of the work piece the sides of the channels are finished. The sides parallel to the axis are finished during the longitudinal movement of the work piece. Finally, a third helical line can be milled by the machine by combining the two previously mentioned movements. A copying tracer is moving in the pattern as a guide. The distance of the copying tracer from the cutter is fixed during the milling. Whenever the tracer reaches a corner in the pattern, a new direction of motion of the work piece must be adjusted. A slipping clutch prevents faulty milling.

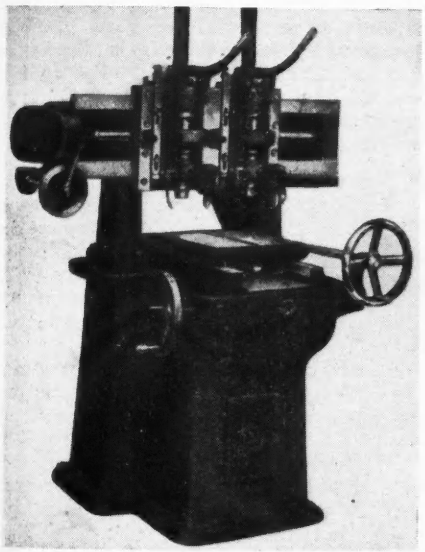


Fig. 15

Fig. 15 shows a copying machine for profiling. It is a standard two-spindle type with motor drive. The table can slide on the surface guides on the bed and is moved in the longitudinal direction by a hand wheel. At the centre of the table there is a guide groove in which the clip plate of the work piece and the pattern is fixed. The slide of the copying arrangement can move diagonally across the table on wide surface guides. The slide is moved by hand. The milling spindle carriage

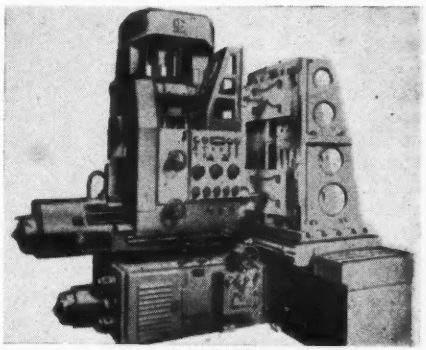


Fig. 16

is fixed on to the slide of the copying device, and can be moved in a vertical direction by a hand wheel. It can be fixed in any required position. A micrometer screw is provided for a very fine adjustment of the slides.

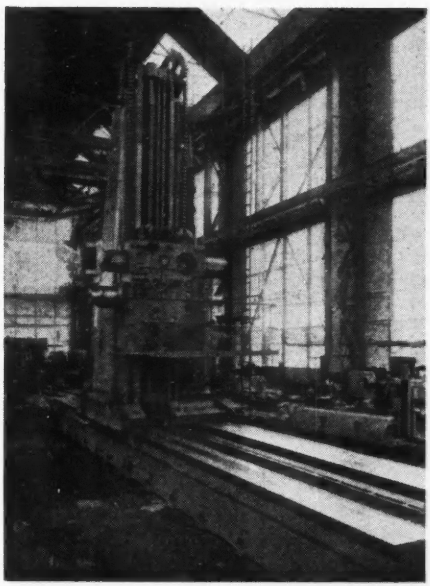


Fig. 17

The copy milling machine shown in Fig. 16 has a fixed column and a sliding clamping device instead of the more usual arrangement with a movable column and fixed clamping device. The principle of operation is as follows : the table with the clamping device for the work piece and the pattern can slide in a horizontal plane along the bed. The milling carriage can move up and down on the column. The saddle can be moved in an axial direction on the slide of the column. For all these movements a single motor is provided, which is controlled by a relay and has a variable speed control. The copying tracer is mounted on the milling carriage, and hence follows an identical path with the cutter.

The horizontal-vertical planing and milling machine shown in Fig. 17 has an unusual design. It was constructed to mill and plane large and heavy work pieces, and to perform other operations on the same piece with portable machines placed on or near the work plate.

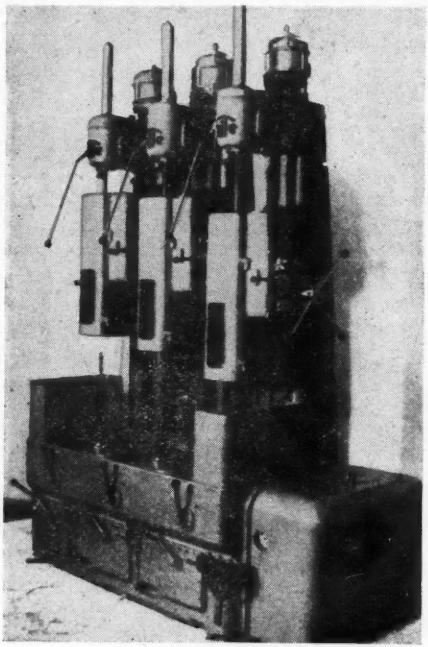


Fig. 19

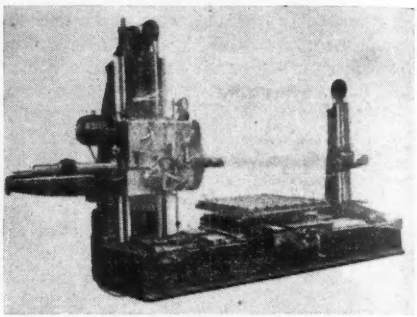


Fig. 18

The machine is made up of the bed, the column which slides on the bed, and the saddle which slides on the column. The spindle sleeves, the cutter and the slide rest of the planing tool are arranged in the saddle. Work pieces of dimensions 9.5 m. width and 4 m. height can be machined on this machine. The drive is provided by a reversible variable D.C. motor attached to the column. Other motors provide the drive for the feeds and traverses.

Boring machines.

Fig. 18 shows an improved boring machine of the fixed column type. The improvements are briefly as follows : a flexible coupling to avoid shock due to the sudden starting up of the electric motors. Hardened and ground gear wheels. An automatic clamping device prevents excessive lift of the table.

A three-spindle vertical deep boring machine tool is shown in Fig. 19. A quick changing device is arranged to avoid loss of time during the changing of the tools. Boring can be done with either rotating spindle and fixed work piece or with fixed spindle and rotating work piece, or with the work piece and the table rotating in the opposite directions. The spindles are driven by a single motor. The lowest row of levers is used to open the casing to introduce the cooling liquid. The next set of levers is used in connection with the changing of the tools. The motors for the spindle and cooling pump are at the right hand end of the machine in a casing. The liquid passes through filters before flowing back to the main tank.

(*To be continued*).

THE PRINCIPLES OF CENTRELESS GRINDING

By DR. ING. RUDOLPH KREHER. (From *Die Schleif- und Poliertechnik*, Vol. 17, No. 4, April, 1940, pp. 47-49).

THE adoption of centreless grinding machines in precision grinding technique is almost general. These machines have two cylindrical grinding discs or wheels arranged to face each other with their cylindrical surfaces. The work piece, lying on a supporting work rest with an inclined upper face, is forced between the discs and is rotated by frictional contact of one of the grinding wheels. The work piece thus acquires a uniform circumferential velocity at all grinding points. The operation of the machine is very simple.

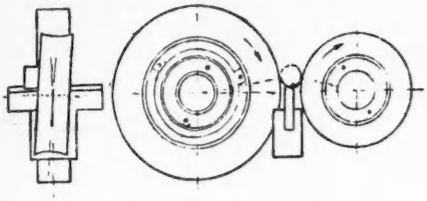


Fig. 1

Fig. 1 shows in sketch the principles of the centreless grinding machine, and Fig. 2 is a photograph of a modern machine of this type.

The advancing motion of the work piece is given to it by the feed or control wheel, which for this purpose must be inclined to the vertical plane, as shown in Fig. 1. Again, to ensure a uniform advance throughout the process, the work piece must lie on the control wheel with its entire length along a line of contact. With an inclined control wheel, this can be only obtained by forming the face of the control wheel to the shape necessary to give this contact. For technical reasons this forming or trimming is performed along a line parallel to the line of contact, and enclosing an angle of 90° with it at the centre of the control wheel (Fig. 3). If the work piece is ground above or below the line joining the centres of the discs, so that the height of the work piece above this line is H and the height of the actual line of contact above the same level is H', then the cutting diamond must be shifted to the right by a length H' (Fig. 3). The height H' can be calculated from the following equation :

$$H' = H. \frac{D_v}{d_w + D_v}$$

where D_v is the diameter of the control wheel, and d_w is the diameter of the work piece.

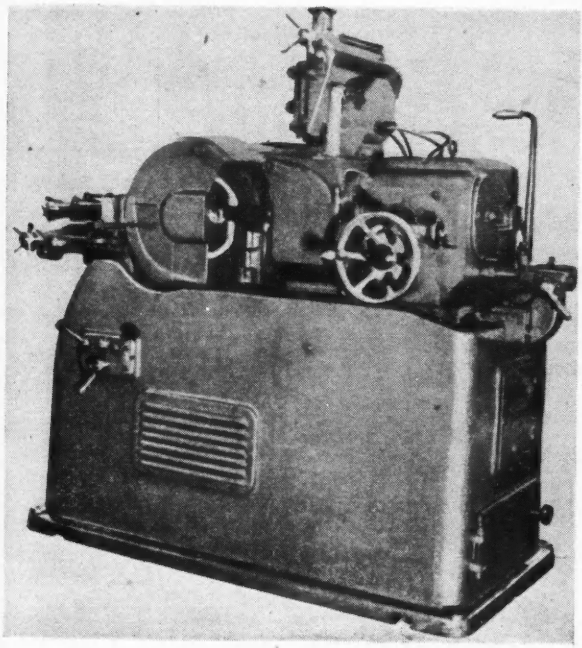


Fig. 2

The practical limits of adjustments.

The following grinding elements can be adjusted on the machine :

(1). The inclination of the control wheel. From 0° to 6°, usually 4°.

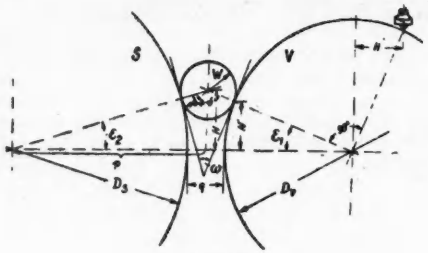


Fig. 3

(2). The circumferential speed of the control wheel (from 10 to 100m./min). Since the work piece is, as it were gripped by the control wheel, this is also the speed of the work piece.

(3). The height H. This is adjusted by raising the supporting piece. The value of H will depend on the dimensions of the work piece and the grinding wheels. The free passage between the wheels must be sufficiently large to put the supporting piece in between, allowing for a suitable clearance as well. The value of H is given by:

$$H = \tfrac{1}{4}\sqrt{4 \cdot a - \left(\frac{a-b+c}{c}\right)^2}$$

where $(D_s+d_w)^2 = a$, $(D_v+d_w)^2 = b$, and $(D_s+D_v+2q)^2 = c$, and

D_s=diameter of the grinding wheel,
D_v=diameter of the control wheel,
d_w=diameter of the work piece,
2q=free passage between the wheels at the centre level.

(4). The depth of cutting. This can be adjusted by moving the control wheel relatively to the grinding wheel. A limit to this is, however, given by the required accuracy of the grinding. The angle of taper should lie between 1:10,000 and 1:1,000.

(5). The angle (σ) of the supporting piece. This is usually between 35° and 90°. A too small angle would mean that the work piece is pressed between the control wheel and the support, instead of the two wheels, hence, no grinding would take place.

The process of grinding.

The rotation of the work piece as well as the grinding starts as soon as the work piece is introduced between the wheels. The instantaneous elastic deformation of the wheels is reduced successively, but it does not vanish entirely. Hence, the diameter of the work piece does not quite correspond to the distance between the two wheels, it is slightly larger. The radial pressure between the work piece and the wheels is the largest at the beginning of the grinding. A certain amount of pressure is required to advance the work piece. The cutting off is also the largest during the first round of grinding and is reduced when the process is repeated.

The grinding wheel has reduced diameters at both ends, Fig. 4. At the front it is shaped so that it will help the introduction of the work piece, and at the end it will prevent excessive cutting. Suitable dimensions of these are given on the Fig.

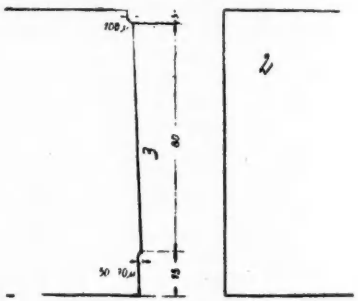


Fig. 4

The advantages claimed for the process.

(1). Accuracy, small deviations of the diameters at different sections from the required diameter.

(2). Small deviations of the longitudinal and cross sections from the ideal form.

(3). The high quality of the surface finishing, without spots or thread-like marks on the surfaces.

The deviations from the ideal circular cross section.

The two characteristic deviations are the variation in the diameters, and the "uniform width." The latter term means that although the cross section is not circular, it cannot be detected by using parallel plates, since it has the same width across any diagonal of the cross section. These two deviations can also be called "two point ovalization" and "three

point deviation," the names corresponding to the process with which they can be detected. Since the actual shape of the cross section of a uniform width is usually determined by a " V " groove, it is also referred to as " V-groove ovalization."

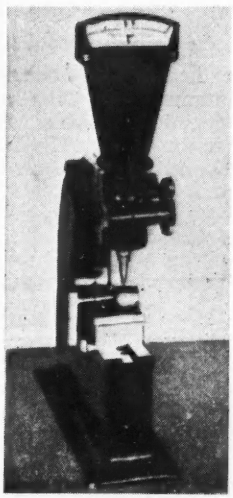


Fig. 5

Fig. 5 shows a V groove measuring instrument. Here the V-groove is replaced by two cylindrical rollers. The V angle is usually 60°. The deviations from a circular cross section can be calculated from the measurements thus :

$$w = dpf - df = \frac{2y \cdot \sin(\sigma/2)}{\sin(\sigma/2) - 1}$$

and for $(\sigma) = 60°$, $w = y/3$.

The letters used for different dimensions are best understood by referring to Fig. 6.

The characteristics of the conditions of grinding.

These are determined by the adjustments of the grinding elements, mentioned previously. The shape of the work piece is mostly influenced by the value of H. The grinding gauge is determined by the angle (w) as shown in Fig. 3. The relation between the angle (w) and the angle (δ) is given by :

$$(w) = 180° - (\delta).$$

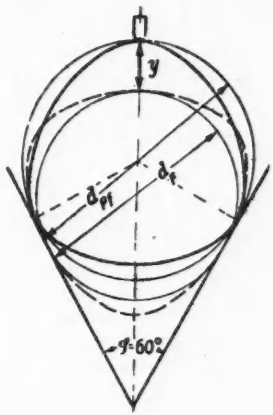


Fig. 6

If the value of H is kept constant the angle (δ) is varying with the diameter of the work piece.

To obtain similar conditions of grinding for different work pieces with different diameters, the following equation can be used :

$$H = \frac{(2d_w + D_s + D_v)}{(d_w + D_s)(D_v + d_w)} \cdot \cos\frac{(\delta)}{2}$$

The index of the letters is the same as before.

If the machine is adjusted so that the centre of the work piece is on the level of the grinding wheel centres, and the next time above it, then we get different conditions of grinding. The effect of this on a uniform width can be examined in Figs. 7a and 7b.

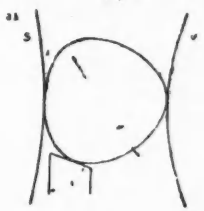


Fig. 7a

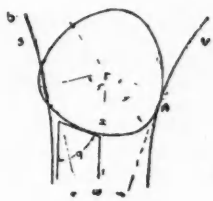


Fig. 7b

If the clearance between the grinding and control wheels is adjusted to a value, say d, than a triangular uniform width will not be ground on the machine if placed on the level if the disc centres, since the work piece is fitting in the machine in every position. If, however, it is placed at a height H and the distance d adjusted suitably, the corners of the triangular width will be cut off as shown in Fig. 7b.

EXPANDING OR CONTRACTING COUPLING FOR WORK DRIVING

(From *Die Schleif- und Poliertechnik*, Vol. 17, No. 4, April, 1940, pp. 62-63).

THE coupling, described below, is a very useful instrument for gripping cylindrical work pieces. It is very easy to handle, and the operation avoids distortion of the work and dispenses with split mandrels. Figs. 1 and 2 show a coupling, the numbers on the figure referring to the following parts:

1. The work piece.
2. The packing or liner.
3. The actual taper sleeve.
4. The cylindrical rollers.
5. The journal of the rollers.
6. The sleeve or stretching ring.

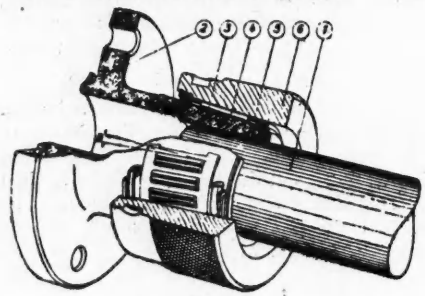


Fig. 1

The rollers are inclined at a small angle to the axis of the coupling. The diameter of the rollers is about 7-8 mm. They are placed between conical inner and outer surfaces. If the operating part is rotated, then it moves along the axis due to the inclined position of the rollers. During the turning-in it will exert a radial pressure on the rollers, which are transmitting the pressure to the sleeve. The sleeve is thus uniformly deformed along its entire surface and

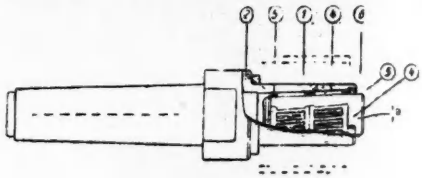


Fig. 2

is pressing against the work piece. If turned in the other direction, the pressure is released. The rollers are self-adjusting so that jammnig cannot occur. The coupling is hand-controlled and requires only a small operating force. Since the required pressure can be adjusted on the coupling, it can be used for light section work without damage.

Advantages of this coupling are that the circular cross section of the work piece is not deformed, and hammering and forcing of the work piece is eliminated.

The hardened parts of the coupling which carry the load are covered so as to be water and dust tight.

The gripping range of a coupling is of the order of about 0.002 times the diameter.

DELIVERY REGULATION OF RECIPROCATING PUMPS

By E. HABLUTZEL. (From *Schweizerische Bauzeitung*, Zurich, Vol. 116, No. 5, Aug., 1940, pp. 56-57).

THE most simple method of regulating the quantity delivered by a reciprocating pump is by speed adjustment.

It may not, however, be always desirable, or possible, to vary the speed of revolution, and in such cases other means of adjustment for variable quantity must be found.

A common method is by throttling the delivery by some form of screw down valve, this has the disadvantage of raising the pressure in the plunger chamber, and hence, increasing the energy consumed by the pump, without useful return.

Another method is to throttle the water, or

other liquid, on the suction side. This involves partial filling of the plunger chamber, the remaining volume being with air, or other vapour, carried in with, or released by, the liquid handled.

Such partial filling is always undesirable, and, in many cases, cannot be allowed.

For oil heated boilers, the delivery from the oil pump must be air free; and when handling volatile liquids the release of gas may easily become dangerous.

Messrs. Sulzer Bros. have evolved a solution of the problem which overcomes all the difficulties mentioned in the following manner: Two pump units, having an equal number of cylinders, are connected by means of an adjustable coupling.

The suction and the delivery of two corresponding cylinders (a_1 and a_2) in the respective pumps, takes place through common suction and delivery pipes (Fig. 1).

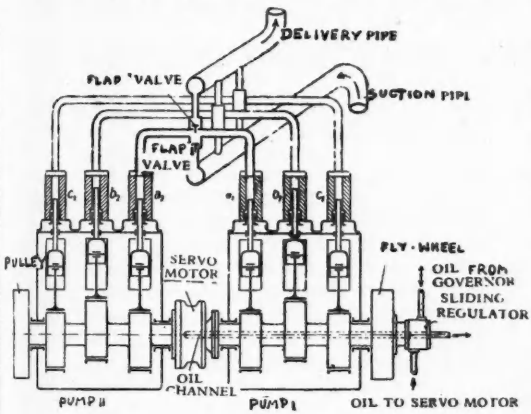


Fig. 1

If the two plungers are operating in the same phase, the total delivery (i.e. the maximum) is twice the delivery of one plunger. If, however, there is a phase difference of 180° between the two plungers, the intake of one is equal to the discharge of the other and so no liquid passes into the common delivery pipe.

It is evident that by suitable adjustment of the phase difference, any required delivery can be obtained between the limits of the maximum and zero, the same applies to each of the remaining pairs of cylinders.

Various designs of adjustable coupling between the two pump shafts are available, one of these being illustrated by Fig. 2.

This shows the servo-motor which automatically adjusts the phase difference between the pump shafts. It consists principally of a casing attached to the driving flange, and a rotary slider forming the driven part. The casing is divided into four chambers, two pressure and two cushion chambers, by means of the slider and two walls in the casing. At maximum delivery of the pump, the slider is directly pushed and, hence, rotated by the walls. A reduction in the delivery can be obtained by arranging for a phase difference. This is done by forcing oil into the compression chambers through the central oil channel. Part of the oil filling the cushion chambers is thus forced back to the main lubricating oil system. The oil pressure in the cushion chambers must be sufficiently large to keep the slider in position, i.e. the slider must be pressed against the walls or against the oil pressure in the compression chamber. To increase the

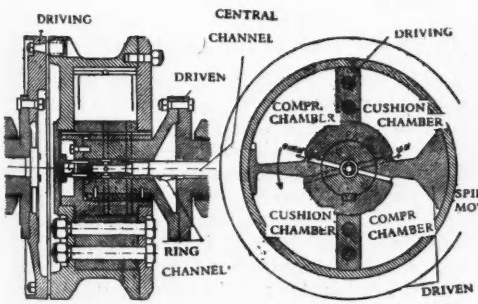


Fig. 2

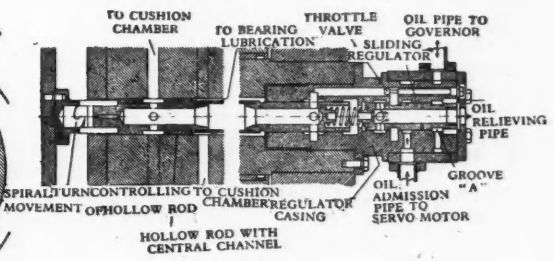


Fig. 3

delivery of the pump, i.e. to decrease the phase difference, oil is allowed to leave the compression chambers, while the cushion chambers are refilled with oil from the lubricating system.

In the present case the phase difference of the shafts is controlled by the oil pressure of the governor pump (Fig. 3). Any increase in the oil pressure of the governor pump means an increased pressure to the left in the ring channel (a), causing the sliding regulator to move to the left against the resisting force of the spring. Thus, the oil channel of the servo-motor is opened to the oil relieving channel through the throttle valve, and by the pressure of the oil in the cushion chambers the slider is rotated towards the walls of the casing, which produces an increase in the delivery. Due to the rotation of the slider, the central oil tube, serving as a rod, is pushed back by means of the spiral turn shown in Fig. 3. The reacting force of the spring is thus increased, and the sliding regulator is pushed to the right until equilibrium of the forces is obtained. Hence, any increase in oil pressure of the governor pump corresponds to a definite phase advance.

A reversed action takes place if the governor oil pressure falls. In this case the force of the spring overcomes the oil pressure and the sliding regulator is pushed to the right, and thus the oil admitting channel is opened to the channel leading to the servo-motor, producing a phase retardation and, hence, a decrease in the delivery. As all regulating parts must have a running fit, there is a certain amount of oil leakage, but this is so small that the oil consumption is quite negligible.

THE CORROSION RESISTANCE OF SINTERED CARBIDES

By W. DAWIHL, Studiengesellschaft für elektrische Beleuchtung m.b.H. (From *Chemische Fabrik*, 1940, April 20th. Vol. 13, No. 8, pp. 133-135).

AFTER the great success achieved in the machining of metals, glass, ceramics, carbon, wood and plastics with sintered carbides, this material was also used for the construction of independent parts placed wherever resistance to wear is of the utmost importance, e.g. on sliding surfaces, valve seatings, tubes and linings for bearings.

These sintered carbides are made mainly from the carbides of tungsten or titanium and a certain amount of auxiliary bonding metal, mostly cobalt. Owing to the method of production of the material, the shape and dimensions of manufactured parts are limited. Their application consists mainly in lining the places where heavy wear is bound to occur. It is possible, however, to form tubes up to one meter in length. The joining of the carbide part to other metals is effected by brazing or shrinking.

These wider applications now found for the sintered carbides made it necessary to investigate their resistance against attack by hot air, acids, alkalies and sea water. The carbides themselves are resistant against hydrochloric, sulphuric and hydrofluoric acid, but are attacked by concentrated nitric or other oxidising acids. The auxiliary bonding metals, however, are mostly soluble in acid, so that erosion of the sintered carbide occurs. For that reason the experiments were also extended to experimental alloys of carbides without any bonding metal and to borides, although the mechanical properties of the latter are inferior to the tungsten and titanium carbides.

The investigations were conducted on small plates, 10 mm. × 20 mm. × 8 mm.; one 10 mm. × 20 mm. surface being ground, the other polished.

Resistance to air of various temperatures.

The layer of oxides formed on the surfaces of the test plates was removed by careful brushing and the loss in weight determined (Table 1).

It is shown that the resistance of WC-TiC-Co alloys against oxidation in hot air increases with the TiC content. Alloys with high TiC content showed an even better resistance, but above 600° C the normal sintered carbides are not superior, and in most cases inferior to alloy-steel. The borides and chromium carbide are resistant to hot air up to 800° C.

Humid air at 100° C had not affected the gloss of the polished surface after 50 hours, nor the atmosphere after five months' exposure.

TABLE 1.

Loss in weight (gm./100 sq. cm./1 hour).

Temp. °C	WC+ 6% Co	WC+ 15%TiC +6% Co	Boride-alloy	Chromium carbide-alloy
600	0.4	0.05	—	—
700	11.0	2.2	—	—
800	44.0	13.5	0.01	0.01
900	67.6	24.5	0.07	0.06
1000	—	—	0.22	0.40
1100	—	—	1.38	1.51

Resistance to sea water.

At room-temperature, fully or half immersed test plates showed no alteration in weight during three months, only a slight brownish discoloration of the surface was noticeable.

Another test was made by placing the test plates on glass beads, half immersed in synthetic sea water at room-temperature with a steady current of air passing through the water. The results described in Table 2 were obtained after three months.

TABLE 2.

Loss in weight (gm./100 sq. cm./3 months).

WC + 6% Co	0.04
WC + 11% Co	0.04
WC + 15% TiC + 6% Co ..	0.04
Sintered carbide without auxiliary metal	0.02

The gloss of the polished surface was slightly tarnished. Carbide plates brazed on steel showed the same behaviour.

Resistance to Acids and Alkalies.

The plates were fully immersed in great excess of the attacking agent. The losses in weight are given in gm./24 hours/sq. m. and compared with Thermisilid-steel and other acid resisting metals (Tables 3, 4 and 5).

TABLE 3.

Loss in weight at room-temperature (gm./sq. m./24 hours).

		WC+ 6%Co	WC+ 15%TiC +6%Co	Sintered carbide without auxiliary metal	Thermisilid
HNO_3	10%	133	67.0	2.0	2.4
„	30%	69.5	—	5.9	2.4
„	65%	89.0	—	—	2.4
HCl	5%	1.2	—	—	2.4
„	20%	26.5	9.0	1.2	24.0
„	35%	86.0	—	1.6	24.0
H_2SO_4	10%	2.4	1.7	1.7	2.4
„	50%	1.2	—	—	2.4
HF	20%	15.0	17.0	1.3	—

TABLE 4.

Loss in weight at boiling range (gm./sq. m./24 hours).

		WC+ 6%Co	WC+ 11%Co	WC+ 15%TiC +6%Co	Sintered carbide without auxiliary metal
HNO_3	10%	173	800	102	48
HCl	20%	400	—	200	4.0
H_2SO_4	10%	154	360	28	2.1
NaOH	10%	5.3	5.5	3.6	3.0

TABLE 5.

Loss in weight at boiling range (gm./sq. m./24 hours).

		Thermisilid	Chromium-alloy-casting	V2A Steel	Tungsten
HNO_3	10%	24	2.4	2.4	144
HCl	10%	240	—	240	24
H_2SO_4	10%	24	—	240	24

Summing up the results, it can be stated that the alloys are stable in hot humid air at 100° C. At higher temperature slow oxidation sets in. The WC- and TiC- alloys can be used up to 600° C, special alloys (CrC or Borides) up to 800° C.

Combined attack of air and sea water leads to a slight brownish discoloration of the surface, but this effect is only so limited that the alloys can be considered as sea water-resistant.

Carbide materials without auxiliary metal are very resistant at room-temperature and at boiling range against hydrochloric, hydrofluoric and sulphuric acid. Hard metal alloys with auxiliary metal are resistant to sulphuric acid and hydrofluoric acid at room-temperature. At boiling temperature the cobalt part is attacked and dissolved; they are not resistant to hydrochloric acid, but fully resistant to caustic soda.

PENDULUM GENERATORS WITH PERMANENT MAGNETS

By V. OLANDER. (From *ASEA Journal*, Vasteras, Sweden, Vol. XVI, No. 12, December 1939, pp. 162-169).

A BELT driven pendulum has always been considered a weak point of hydro-electric plants. Besides, it was found preferable sometimes to arrange the pendulum not in the vicinity of the turbine. The disadvantages of a pendulum driven mechanically from the turbine have been overcome by the electrical pendulum drive, the pendulum being directly coupled to a synchron motor, preferably of the reaction type which does not call for any (D.C.) excitation. Energy is supplied to this motor from a generator mounted on the shaft of the turbine, the pendulum generator. It has ever been aimed to give to this generator a most simple design. The new ASEA type of pendulum generators with permanent magnets has no windings on the rotating parts, and, moreover, one could renounce the use of D.C. for excitation.

When designing this new type of machines, it had to be considered that a certain model should be capable of application at many different turbine speeds and generator sizes, and even for large diameters of shaft. The result was that these generators receive a large diameter compared with their output of 1 to 1.5 kVA. The length of the core may be short evidently, f. i. 120 mm. for two generators with 1220 mm. air gap diameter supplied for the main generators of the Länghas power station (23,000 kVA, 93.8 r.p.m., 6600 V, 50 cycles). These pendulum generators have a three-phase output of 1.5 kVA at 380 V, $\cos\gamma = 0.2$, 18 3/4 cycles (24 poles).

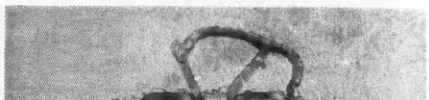


Fig. 2
Partly assembled rotor with magnetising apparatus.

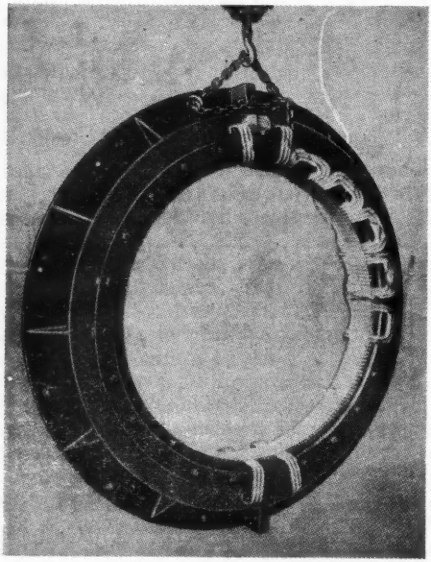


Fig. 1
A partly finished stator.

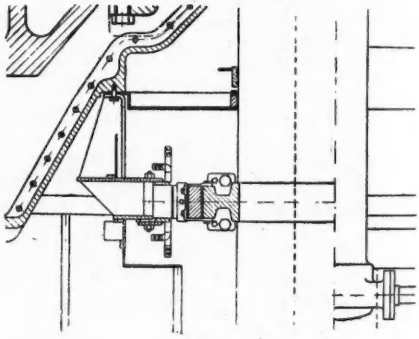


Fig. 3
Pendulum generator mounted on the shaft of the main generator.

The welded stator frames are split for simplification of erection and dismantling. At the two stator joints the winding is provided with coils, which join at the rear, so that cutting through the coils is avoided (Fig. 1). The rotor (Fig. 2) is designed with a rotor ring of non-magnetic material, poles and pole plates are of wrought iron. The magnets made of "Alni" steel are placed between the poles and retained in their places by stirrups of non-magnetic material. The short-circuit windings arranged round every pole protect the magnets against demagnetisation in the event of a short-circuit. Fig. 3 shows the pendulum generator in its place underneath the rotor of the main generator.

The "Alni" steel, of which the magnets are made, is a comparatively new type of steel, composed of 11% aluminium, 28% nickel, and the rest iron and slight quantities of carbon, manganese and silica. It has a coercive force of 500 oersted (formerly employed low percentage chromium and tungsten steels had a coercive force of about 60 oersted) and a remanence between 5,000 and 6,000 gauss. These properties qualify this type of steel best for use as magnets in a generator. Fig. 4 shows a part of the Alni steel hysteresis curve.

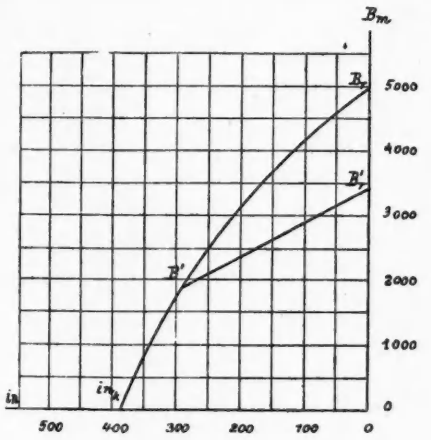


Fig. 4
Hysteresis curve of "Alni" steel.

A special procedure has to be applied in order that the magnets, when inserted in the rotor, may retain as much as possible of the induction produced in the magnetising apparatus. When a magnet would be taken out of the magnetising apparatus, which forms a complete short-circuit for the magnetic flux, the magnet would loose a great deal of the induction produced in the magnet when magnetised in the apparatus, due to the increase of the resistance in the magnetic circuit, f.i. the induction would drop to a point like B' (Fig. 4). When the magnet would then be introduced again into the magnetising apparatus, the induction would rise even without magnetising current, but not following the hysteresis curve, but approximately following a straight line up to a limit value B_r' which lies considerably below Br. This line $B'B_r'$ is stable so far as after a few hundred cycles as described the curve will only have sunk by 5% or so and is fully stable then.

In view of this behaviour, the magnets have to be shifted from the magnetising apparatus over to their place in the rotor without coming into the free air for any part of the path, in order that the line $B'B_r'$ may be situated as high as possible. Fig. 2 shows a magnet just magnetised in the magnetising apparatus resting on the rotor ring and being inserted half way down between the pole cores. The line $B'B_r'$ in Fig. 4 corresponds approximately to the conditions prevailing in the Länghas generators.

It is not difficult to calculate the dimensions of the magnets of a pendulum generator, when the quality of the steel to be used is known and the behaviour of the magnets, as described before, is taken into consideration. Exact calculation is necessary, as these machines give a voltage, which cannot be adjusted by regulating an exciter current. The original publication gives an abstract of the calculation of the Länghas machines.

ASEA has standardised 3 types of pendulum generators to be placed between the rotor of the main generator and its exciter. Since for these generators splitting of the machine can be avoided, they will be considerably cheaper than the Länghas machines. The standardisation covers main generators from 83 up to 1,000 r.p.m. with a maximum shaft diameter for the pendulum generator of 650 mm. for 83-250 r.p.m., 450 mm. for 300-428 r.p.m., and 350 mm. for 500-1,000 r.p.m.

X-RAY POLE INSPECTION

By MYRON ZUCKER. (From *Electrical World*, Vol. 113, No. 12, 1940, March 23rd, pp. 33-35).

THE new method is to take X-ray pictures through the poles as shown in Fig. 1. Sufficient research work has been done by the Detroit Edison Company to indicate that X-ray inspection is accurate, practicable and economical, although there are still unsolved problems and unanswered questions. The method is based on the fact that the pictures of good, sound wood differ from those of rotten wood, the structure of the fibre being an indicator. Film density is a supplementary indicator.

A series of breaking tests was made on poles, which were inspected by boring in the usual manner, and by X-rays. The strength calculated from X-ray pictures averaged 16% more than the actual strength found by the breaking test. Several poles cracked at the boring test plug when tested. Inspection of the 300 poles of an area by the method of boring condemned 28 poles, X-rays condemned 8 of them, plus two different ones. Thus, X-rays gave at least three years more to 20 poles. The amount of saving in pole replacement covers fully the higher cost of the X-ray inspection. Moreover, it is of great value that X-ray inspection removed poles, which otherwise would have remained as hazards to service. It is a valuable feature of the new method of inspection that it leaves records by which the progress of the rot can be studied and future strength calculated.

It has been found the best method to make pictures directly on a film of sufficient sensibility, wrapped in light-proof paper, and exposed as shown in the illustration. At first there was encountered the difficulty that if the film was properly exposed for the centre of the pole, the edges became too black, as too many X-rays penetrated here. Elaborated study ended with strapping a simple rubber X-ray absorbent girth around the poles. This evens the film density.

The first mobile set of the Detroit Edison Co. used a Westinghouse Diadex X-ray machine rated at 85 kV, 15 milli-ampere anode current mounted on a sliding shelf in a spring supported cabinet near the tailboard of the truck used. A 2 kW two-cylinder air cooled gasoline engine and a single phase self-exciting generator feeds the X-ray machine with 110 V 50 cycles. Agfa non-screen films 7″ × 17″ are used. The right time for the exposure has been tabulated according to dimensions and quality of the poles. A timer de-energizes the X-ray tube when the film is properly exposed.

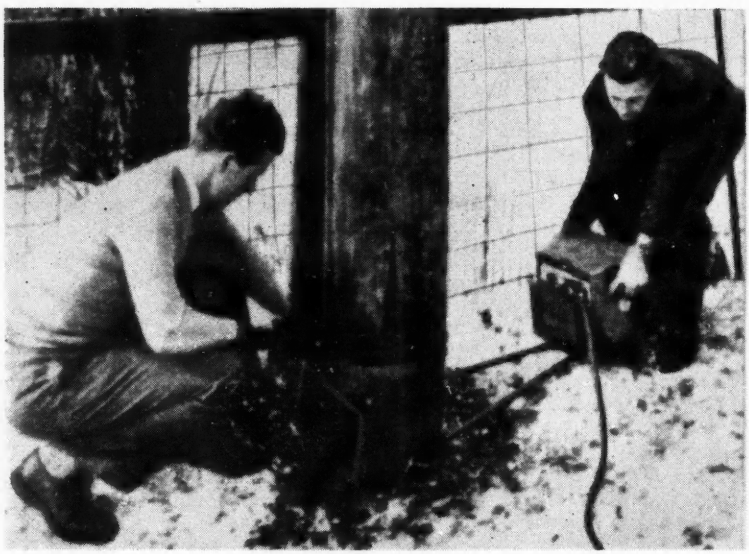


Fig. 1

LIGHT METAL FORGING IN MOULDS

By BERNHARD PREUS. (From *TZ für praktische Metallbearbeitung*, January, 1940, pp. 28-29).

DURING the hot working of light metals, the characteristics of the deformations are different if the forming is done by applying a pressure or by hammering. Referring to the specimen shown in Fig. 1, the centre height of the eyes could be more readily obtained by hammering than by pressing, since the metal would be given less time to flow, and hence, it remains in the required position, i.e. more in the mould than in the burrs.

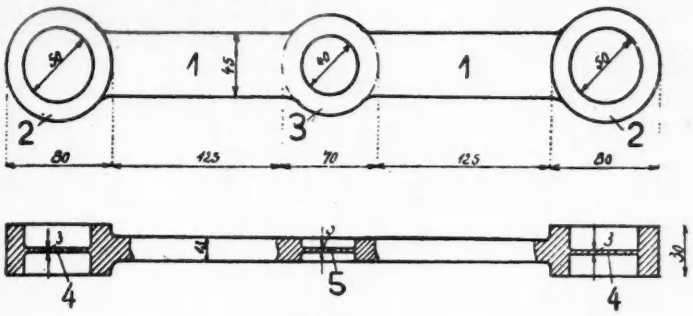


Fig. 1

With more complicated pieces, however, a hydraulic pressure is better, since the correct arranging of the crystals of the metal require some time, during which a higher pressure should be applied.

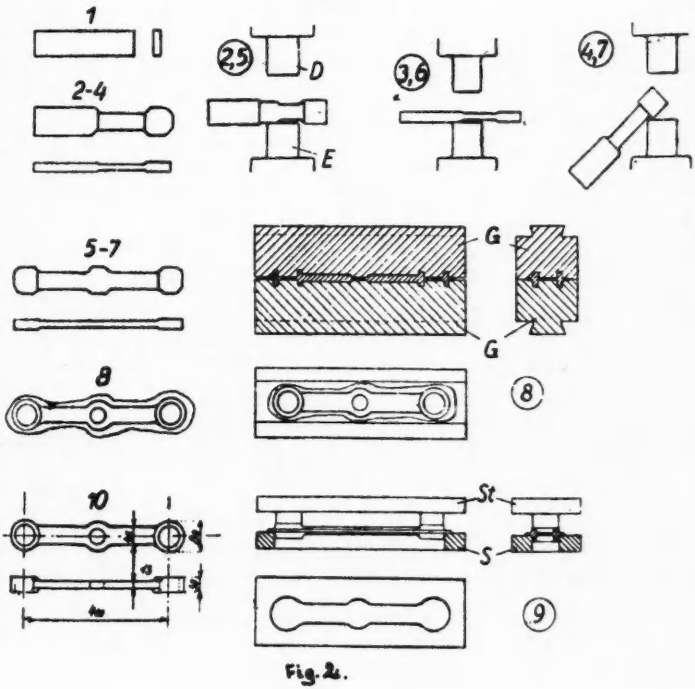


Fig. 2.

The forging temperatures of the specimen shown must be kept between narrow limits, about 330°—380° C., and in special cases only can be increased to 400° C. Light metals cool much quicker than other metals and frequent reheating is required.

The limits of the temperatures must not be exceeded during forging, cooling and quenching. As overheating of the castings is to be avoided under all circumstances, electric furnaces are usually employed, since these can be reliably adjusted to the required temperatures.

Determination of the weight of the charge.

Corresponding to the finishing shown on Fig. 2, the most suitable initial cross section is 70 mm. × 20 mm. The 3 mm. excess thickness of the edges will be milled off with a milling machine. To avoid this last operation, a special die should be made, which, however, would only prove to be economical if a large number of pieces are to be produced. The estimation of the different sections of the specimen gives a total weight of:

W = ..	..687 g.
Safety 2%	.. 13.7 g.
Wastage 2%	.. 13.7 g.
GRAND TOTAL	714.4 g. or 0.72 kg.

Determination of the initial length.

If the charge is to be 0.72 kg. and the width =b, the height=h, then the cross section is:

$$b \times h = 7 \times 20 \text{ mm.}$$

hence W=L.b.h.s.

Where L is the initial length, and s is the specific weight of the metal, and hence:

$$L = \frac{0.72}{0.7.\ 0.02.\ 1.81} = 280 \text{ mm.}$$

Forging according to the working plan 2.

Material Mg. ALG. Specific weight 1.81.
Strength in compression 40-45 kg./mm².
Strength in tension 28-32 kg./mm².
Weight of charge: 0.72 kg.

For preliminary forging 100 kg. air hammer to be used.

For forging in the mould 3,000 kg. stamp hammer to be used.

Labour: 2 men for the preliminary forging,
1 man for the forging in the mould.

Working Process.

If the specimen is heated to the required temperature in the stage (1), then stage 2-4 will be forged with this heating. This part of the processes need not be finished very accurately. During the preliminary forging, two reheatings will be required in order to keep the temperatures at the correct value.

For the mould forging the work piece must be reheated again, and the specimen is placed in the warmed mould. The warming of the mould is very important to avoid losing heat from the work piece. Hammering in stage (8) follows. During the stage (9) the stamping is trimmed along the section S and finally form 10 is obtained.

The bores of the eyes are only prepared according to stage 8 in the mould if they exceed 30 mm. diameter. The flatting of the thin ground plate is done by opposed hammer blows, i.e. two hammers are used, hammering in the opposite directions with the same force. This is not so harmful to the mould and avoids jamming of the work piece in the mould at the same time.

TABLE OF THE PROCESS.

	Free forging.	*Minutes.*
(1).	Keeping the specimen in the furnace ..	0.25
(2).	Portion of the fire pocking	0.80
(3).	Portion of the reheating	2.50
(4).	To take it from the furnace	0.33
(5).	To take it from the forging hammer ..	0.10
(6).	Forging No. 1 to 7	4.75
(7).	Storing of the semi product	0.12
	For two workmen together $\frac{8.82}{8.82}$ minutes	
	Mould forging.	
(8).	Keeping the specimen in the furnace..	0.25
(9).	Portion of the fire pocking	0.32
(10).	Portion of the reheating	1.00
(11).	To take it from the furnace	0.30
(12).	To take it to the mould hammers ..	0.08
(13).	To put it in the mould	0.12
(14).	Hammering according to No. 8 ..	0.95
(15).	To take it to the trimming press ..	0.08
(16).	Trimming according to No. 9	0.28
(17).	To take it to the storing place ..	0.10
(18).	Storing the finished specimen	0.14
	Finished form total	21.26
	Loss of time 12%	2.65
	GRAND TOTAL	23.91

Index to the figures on the illustrations.

Ordinary figures denote stages of work, showing the work piece after the stage.

Figures in circles denote the specimen during the respective working stage.

Further D=hammer head saddle.
G=bottom hammer saddle.
S=trimming section.
St=trimming press.

LIGHTNING OUTAGE RATE REDUCED 80 PER CENT.

By R. M. SCHAHFER and W. H. KUNTZ. (From *Electrical World*, No. 26, Vol. 113, June 29th, 1940, pp. 41-42).

Steel tower transmission lines.

For the 7 years previous to 1937, the 163 circuit miles of 132 kV steel tower transmission lines of the Northern Indiana Public Service Co., though they were equipped with an overhead ground wire, averaged 10.74 lightning outages per 100 miles per year, with a maximum of 14.39 for a single year. The company, after comparison of operating records and of construction of lines in adjacent territory, came to the conclusion that high tower footing resistance was the factor causing the poor record. By proper grounding co-ordinated with insulation flash-over the line has been made fairly immune to lightning since 1937. An average of 1.97 outages per 100 miles/year for the improved lines has been experienced for the last 3 years. The tower footing resistance which would enable the towers to withstand, without flash-over, a lightning current of 150.000 A was approximately 5 Ohms.

Wood-pole transmission lines.

The theory of co-ordinating flash-over voltage with grounding resistance holds as well for wooden poles, of course. A 48 miles 66 kV line built by the company in 1938, according Fig. 1, had no outage due to lightning. In steel tower line design there is one flash-over path across the insulator and one by air to the nearest member of the tower. In a wood-pole transmission flash-over paths have to be considered from each conductor by air to the overhead ground wire or across porcelain and wood to the overhead ground wire or to the down lead ground wire. It was felt that the impulse strength of all paths incorporating wood should be somewhat greater than the impulse strength of the shortest air path from conductor to ground. This is to insure that any flash-over would follow the air path and thus damage to wood would be minimized. The required difference in impulse value of the two paths may be easily obtained by setting the down lead ground wire away from the pole by means of arms or extension bolts (Fig. 1). By this arrangement, very high flash-over values of the wood-pole line can be secured. The ground resistance, to enable a structure such as is shown in the illustration to withstand successfully lightning currents of 150.000 A, is calculated to be approximately 6 Ohms.

Another 45 miles 66 kV wood-pole line of the company had as much as 47.6 trip outs per 100 miles/year from lightning before 1938. No more trip outs occurred since an overhead ground wire was added, the grounding down leads being brought down on 3 ft. extension bolts, as shown in Fig. 1, and low grounding resistances were secured.

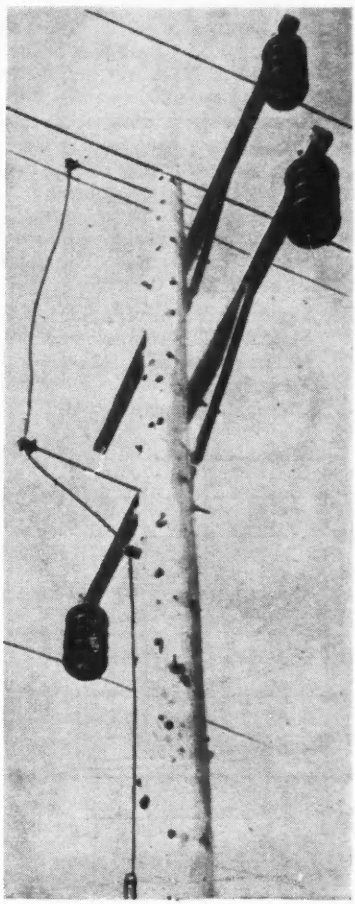


Fig. 1

SURFACE TEMPERATURE MEASUREMENTS BY VISIBLE ISOTHERMAL LINES

(From *Technische Rundschau*, Bern, Vol. 32, No. 28, 12th July, 1940, p. 3).

KNOWLEDGE concerning the surface temperatures of bodies, e.g., air-cooled cylinders, etc., is very desirable, as it enables the engineer to construct such parts with greater economy and more uniform temperature distribution.

Until quite recently such temperatures were measured by means of thermometers and thermo-couples. The isothermal lines were obtained by joining the points having the same temperature. This method, however, is very lengthy and not very accurate, especially when employed on thin engine parts. Further, the thermo-couples conduct away part of the heat, and they also disturb, in many cases, the operation of the cooling system.

On account of these drawbacks, coloured painting materials have been employed recently to determine the isothermal lines. For this purpose, the surface of the machine or machine part is covered with a special paint, which has the characteristic of changing its colour at certain known temperatures. The following are some of the suitable substances :

(1). Mercuryiodide-silveriodide.
(2). Mercuryiodide-copperiodide.
(3). Mercurysulphate.
(4). Mercuryiodide.
(5). Cadmiumcarbonate.

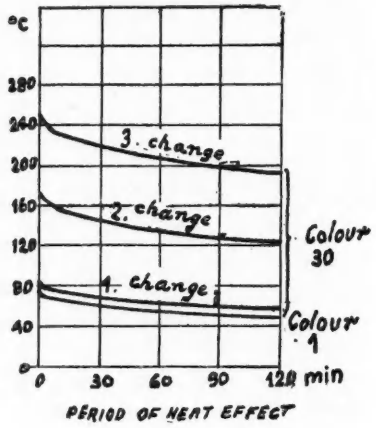


Fig. 1

The first two of these have the disadvantage that they change back to the original colour after cooling down. Hence, they cannot be employed to those parts of the engine which are not visible when the engine is working. On the other hand, colours 3-5 do not give a uniform colouring, and the boundaries are not distinct.

The ideal requirements of such paints are as follows :

(a) Quick change of colour at the respective temperatures.

(b) Permanent change in colour, remaining constant after cooling down.

(c) Easily distinguishable colours at the various temperatures.

Several substances were found to satisfy these requirements more or less, and some of them change colour at several temperatures, e.g. colour No. 30 (Producers' calibration) is pale green when cold, pale blue at 65° C., dark green at 145° C., and greyish brown at 220° C.

The accuracy of this method is naturally not too high. But the main requirement is to determine the temperature distribution rather than the actual temperatures at any particular point. The accuracy of the method is $\pm$ 5% approximately.

The temperature at which the change in the colour occurs depends partly on the duration of the temperature. Fig. 1 shows how the change of colour depends on the duration of the temperature. The colours will readily disappear, and the paint turns back to its original colour under the action of excessive moisture (provided they are cooled down). This is a very desirable characteristic, when the experiment has to be repeated several times.

The paints undergoing only one change of colour are used when a particular isothermal line has to be determined, whereas those changing colour several times are used when a wide range of temperature is to be investigated.

To keep the heat radiation and the conductivity unchanged, only a very thin layer of paint should be employed, usually 0.03-0.07 mm. thick.

The field of application of this method is very wide. As an example it can be employed on the rotor of an electric motor, and thus overloading can be detected. By choosing a suitable shape for the engine part, corresponding to the isothermal lines, a uniform temperature is obtained on the surface. Fig. 2 shows the most suitable shape of a radiator in view of the above mentioned requirements. To obtain accurate results, care must be taken to avoid compensation of temperatures at the end of the measurements. Thus, f.i., when the isothermals of a bearing say, is measured, the cooling system must only be switched off after complete cooling down has taken place, otherwise heat would flow to the cooler part of the bearing, which would not take place during the actual operation.

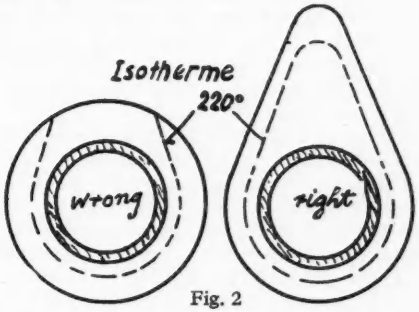


Fig. 2

THE RELATION BETWEEN OCTANE AND CETENE NUMBERS

By Prof. Dr. Ing. W. Wilke, Mannheim. (From "*ATZ*" *Automobiltechnische Zeitschrift*, March, 1940, pp. 148-149).

Although the relation between the Cetene and Octane number was known to be such that a fuel having high anti-knock value in petrol engines gives a very poor performance in Diesel engines, and vice versa, the early experiments carried out to determine the actual relationship between the two scales were not consistent. Von Dumanois and Boerlage investigated this relationship, independently from each other, and the results they obtained are shown in Fig. 1.

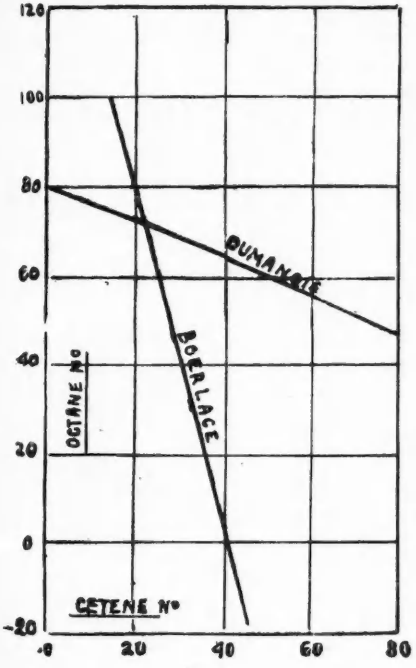


Fig. 1

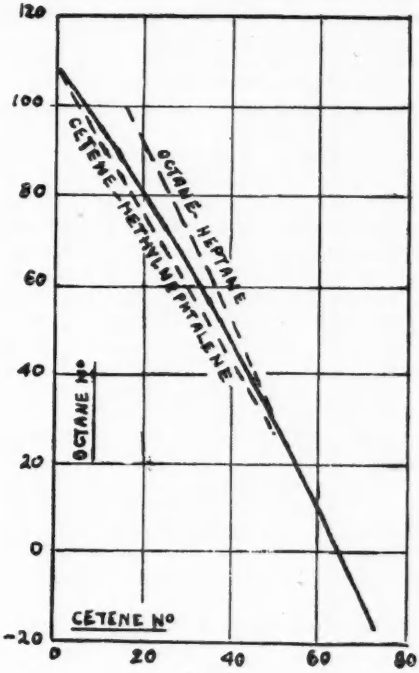


Fig. 2

These unsatisfactory results induced the "Technische Prüfstand Oppau" to establish the real relationship between Cetene and Octane numbers. Experiments were carried out on a large number of fuels, with various mixtures of Octane-Heptane and Cetene-Methylnaphtalene. For the experiments, a C.F.R. motor and an I.G. Diesel engine was used.

Although a small difference was found with Octane-Heptane and Cetene-Methylnaphtalene mixtures, a very distinct relationship could be established, and a mean line drawn, giving very nearly true values. The results are shown in Fig. 2.

It can be seen from this graph that the Octane line is somewhat above the mean line, and the Cetene line is below it. A straight line giving the mean values could be drawn, which passes through the Cetene No. 10 and the Octane No. 100.

Hence the relationship can be expressed mathematically in the following way:

(Cetene No.)=60—0.5 (Octane No.)

and (Octane No.)=120—2 (Cetene No.).

In other words, the increase in the anti-knock value for Otto fuels is 2 Octane number for a decrease of 1 Cetene number in the readiness of ignition. Also from the graph, commercial petrol with Octane No. 74 has a Cetene No. 23, and commercial Diesel fuel of Cetene No. 45 has an Octane No. 30.

A SIMPLE OIL PURIFIER

By DIPL. ING. K. W. BURGDORF and ING. H. FASBENDER. (From "*TZ*" *für Praktische Metallbearbeitung*, Vol. 50, No. 7-8, April, 1940, p. 181).

THE DEROP oil purifier, shown in the figure, consists of a container, a filter placed in the container, the filtering action of which is raised by the action of a siphon connected to the filter. A mud draining cock is provided at the bottom of the container.

The apparatus is very simple, can be readily made up in any workshop, and gives very good results in cases where a mechanical purification of the oil is sufficient.

It is advisable to provide a heating coil in the container. This reduces the viscosity of the oil to be purified, hence an easier passage through the filter is obtained. It also separates water particles from the oil, and further, it provides a preliminary filtration because, due to the reduced viscosity, the larger particles of impurities will settle down and can be drained off from the container. Care must be taken, however, to prevent local overheating of the oil and hence, the maximum temperatures employed should not exceed 60-80° C. It is advisable to admit the oil to the container through a pipe fitted with a filter.

The filter itself consists of a cylinder welded together from a piece of punched sheet metal. Two circular sheet metal pieces are welded to the edges of the cylinder so as to form a drum. The axis of the drum is made of a punched pipe, the upper end of which is connected to the pipe which serves as a siphon. Several

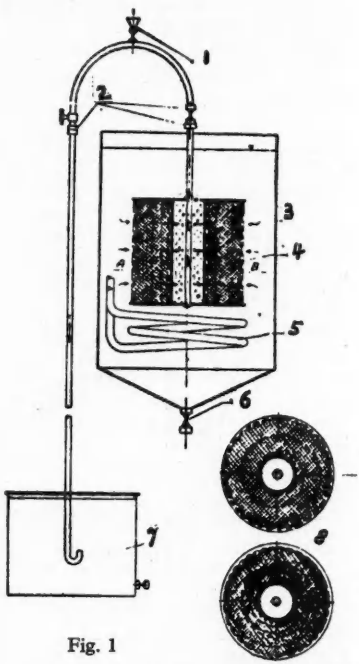


Fig. 1

(1) Filling funnel; (2) Pipe joints; (3) Oil container; (4) Filter; (5) Heating coil; (6) Draining tap; (7) Tank for cleaned oil; (8) Cross section of filter.

layers of filtering materials are wound on the drum cylinder. The siphon is provided with a tap on the highest point in order to fill up the pipe with clean oil. The lower end of the siphon is turned upwards to prevent air bubbles from getting into the pipe, and thus spoil the siphon action. For the same reason, the filter in the container must also be fully immersed in the oil, so that air cannot be sucked through the filtering layers.

AIR RESISTANCE OF MOTOR CYCLES

By Ing. E. Sawatzki and Ing. L. Huber. (From *Deutsche Kraftfahrtforschung*, Vol. 18, 1938).

Experiments were carried out in Germany to investigate the air resistance and to determine the drag coefficient of various types of motor cycles. Only the results obtained for a " R 5 " motor cycle, manufactured by the Bayerische Motorwerke, are given, the other results being almost identical.

The arrangement of the experimental wind tunnel is shown in Fig. 1, where (a) is a polished ground plate. The motor cycle is suspended by two 1.2 mm. diameter steel wires. To approach conditions of reality, the wheels were driven at an appropriate speed by an electric motor, and during the second part of the experiment, the driver was replaced by a doll. Since the front holding rope is inclined at 45° to the horizontal, from the triangle of forces $W_L = W_1$, i.e. the air resistance acting on the vehicle is the same as the force acting on the spring balance and is thus indicated on the scale.

The drag coefficient can be calculated from the equation :

$$C_w = \frac{W_L}{q.f}$$

where W_L = resistance of air in kg.

$q = v^2/_2$.

$= 1/8$ = air density kg. sec.$^2/_{m^4}$.

v = velocity in m/sec.

f = exposed surface area in m^2.

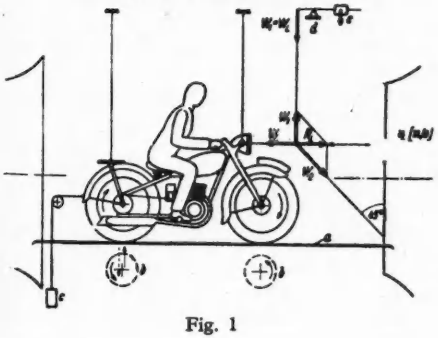


Fig. 1

The experiments covered a range of v = 20-45 m/sec., corresponding to a vehicle speed of 72-162 km./hour.

The experiment was repeated for several combinations of the vehicle fitments, namely, a, b, c, d, e, f, g, under a streamlined cover. a refers to the motor cycle as delivered by the manufacturers.

The capital letters A, B, C and D refer to the position of the driver.

Fig. 2 shows graphically the air resistance speed relation.

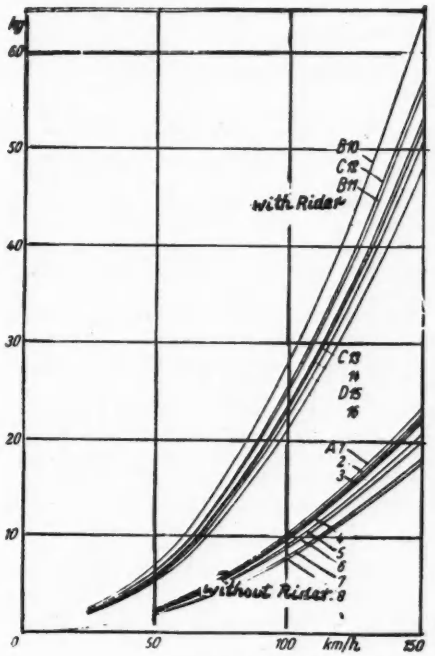


Fig. 2

A = without Rider ; B, C, D = with Rider.

RESULTS.

Exp. No.	Covering	Air resist. kg. at V=km./h 50	100	125	150	C_w	– % of A 1
A 1	a	2.59	10.40	16.20	23.40	0.670	100.0
2	b	2.59	10.40	16.20	23.40	0.670	97.5
3	b, c	2.52	10.12	15.80	22.80	0.653	95.5
4	b, d	2.47	9.90	15.47	22.35	0.639	94.0
5	b, c, d	2.43	9.76	15.24	22.00	0.629	88.2
6	b, e, f	2.28	9.16	14.30	20.65	0.590	85.5
7	b, c, e, f	2.21	8.86	13.84	20.00	0.571	77.5
8	b, c, d, e, f	2.00	8.02	12.52	18.10	0.517	76.5
9	b, c, d, e, f, g	1.96	7.88	12.30	17.78	0.507	76.0
B 10	a	7.06	28.30	44.20	63.80	—	—
11	b, c, d, e, f, g	6.25	25.00	39.15	58.50	—	85.8
C 12	a	6.34	25.40	39.60	57.30	—	—
13	b, c, d	5.89	23.60	36.90	53.30	—	—
14	b, c, d, e, f, g	5.78	23.20	36.20	52.30	—	91.3
D 15	b, c, d, e, f	5.61	22.50	35.15	50.80	—	—
16	b, c, d, e, f, g	5.31	21.30	32.25	48.10	—	94.7

Note: A 1 to A 9 experiments without driver.
B 10 to B 11 driver sitting upright.
C 12 to C 14 driver in bent down position.
D 15 to D 16 driver in upright position, but with streamline covering.

ELECTRIC CONDUCTIVE AIRPLANE TYRES

(From *Flugwehr und Technik*, Zürich, Vol. 2, No. 5-6, June, 1940, pp. 126-7).

HIGH speed air planes accumulate electrostatic charges, which should be conducted to earth in the moment of landing. One has tried, therefore, to develop rubber compounds of good electric conductivity.

In order to make the measurement of the conductivity of the tyres under practical working conditions, the laboratory of "Pallas" Products (R. & E. Huber AG., Pfäffikon) has adopted the arrangement shown in Fig. 1.

A condenser C of 2μ F is charged to E_0= 500 V and discharged through the tyre by turning over switch S to position 2. Within t seconds the condenser will have discharged to

$$E = E_0 \cdot e^{-\frac{t}{CR}},$$

where R is the resistance rim-earth. Hence

$$R = \frac{t}{C \cdot \ln \frac{E_0}{E}}$$

When E_0 has fallen to E=100 V within t seconds, then

$$R = \frac{t}{\frac{2}{10^6} \cdot \ln \frac{500}{100}} = 311.000.t.$$

Tyres of normal type take a very long time for discharge, as the resistance of a tyre of normal rubber may be cca 7000 MΩ. But with special rubber compounds the time of the discharge could be reduced to 1 sec. or even less. The resistance of these types is only about 200.000Ω; one may call such types electric conductive.

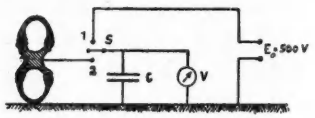


Fig. 1.
C=Condenser 2μ F; V=Static Voltmeter; S=change- over switch.

A BOMB-PROOF STAND-BY STEAM POWER PLANT OF THE TOWN OF BERNE

By E. BAUMANN. (From *Bull. Assoc. Suisse des Electriciens*, Vol. 30, No. 26, Dec. 27th, 1939, pp. 786-9)

(This abstract has been completed by some data given by W. Roth, in "A Modern Stand-by and Peak-load Steam Power Station built as a Bomb-Proof Plant," Brown Boveri Review, Aug., 1939, pp. 193-201).

THE municipal electricity works of the town of Berne erected in 1939 a new stand-by and peak-load power station of 9,000 kW output. In consideration of the risk of a war, it was decided to build this plant bomb-proof.

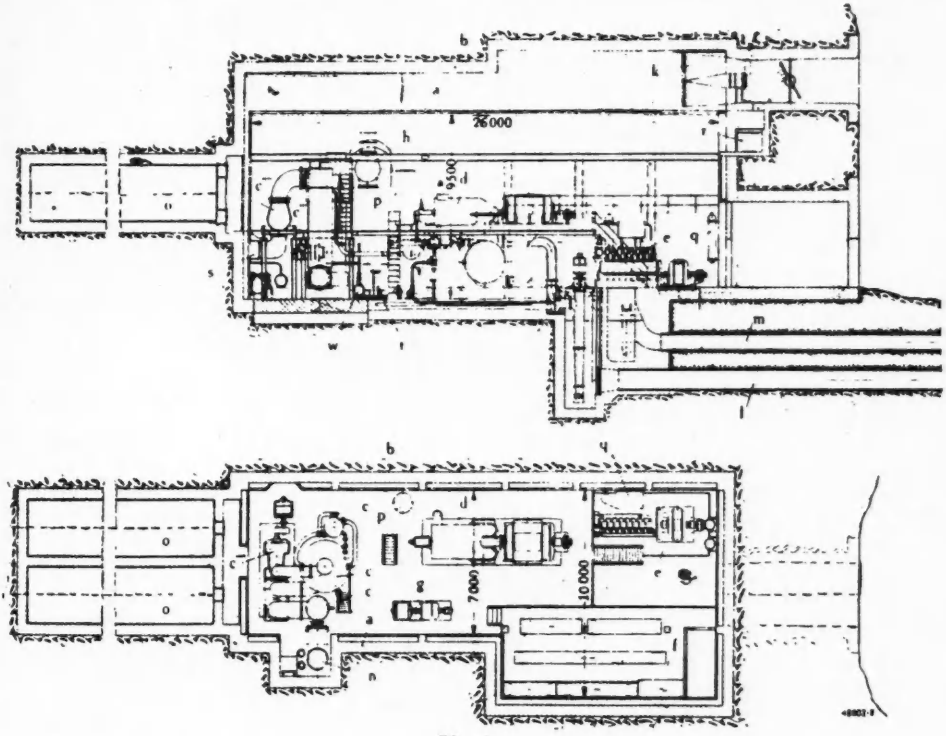


Fig. 1

(a) Inner lining of tunnel.
(b) Masonry work of tunnel.
(c) Velox steam generator with Water steam separator (c′) ; Economiser heated by exhaust gases (c″) ; Circulation pump (c‴) ; Charging set (c⁗).
(d) Turbo set with generator and condensing plant.
(e) Diesel-set for starting the plant.
(f) Switch-gear.
(g) Ward-Leonard set of Velox steam generator.
(h) Feed water tank.
(k) Fan for ventilation.
(l) Channel for cooling water intake.
(m) Overflow and outlet channel.
(n) Exhaust-gas pipe.
(o) Main fuel tank.
(p) Auxiliary fuel tank.
(q) Tank for Diesel engine fuel.
(r) Tank for cooling water of Diesel engine.
(s) Combustion air for Velox.
(t) Preheater of fuel with filter.
(w) Feed water pump.

An underground lay-out was chosen, and the most suitable form thereof was found to be a horizontal tunnel, the dimensions of which are approximately those of a two track railway tunnel (Fig. 1). The plant is located in a steep rising rock near the river Aare, from which the water necessary for a condensing plant could be secured. Therefore, it was decided to build the plant as a steam power plant, and to take advantage of the recent development of steam generation in providing a Velox steam generator.

The dimensions of the engine room can be found in Fig. 1. They correspond to a total volume of about 2,300 m³ for engine-room and switch-gear plant; the volume of this new cca 10,000 kW plant is not greater than that of the boiler-house of the 2,500 kW plant of Berne erected in 1904.

Between the armoured entrance door and the engine room there is a spacious room of 7.5 m. Above this entrance, a propeller fan is installed ventilating the plant and providing for a maximum delivery of 50 m³/sec., driven by a motor of shunt commutator type, the speed of which can be varied over a wide range. The air is carried away from the engine room by a vertical shaft of a length of 15 m. approximately. This shaft can be used as an emergency exit, climbing irons being provided. The same shaft is used to carry the exhaust gas pipe of the Velox, and several other pipes running from the engine room to the open air.

The water for the condensing plant (0.5 m³/sec. for full load) is taken from a concrete shaft connected with the river. The discharge is through a separate shaft, which leads the water back into the river. Provision is made that the supply of water may be sufficient, even in the case that the weir in the river should be damaged by bombing.

There are two fuel tanks attached to the engine room of a capacity of 160 m³ each (length 22.5 m., diameter 3 m.).

Equipment of the station.

The Velox generator, set up in the back of the engine room, has an output of 42 t/h of 24 kg./m² abs and 415° C at the boiler outlet. Compression of the combustion air (pressure 2.5 kg./cm.²) is accomplished by a compressor driven by an exhaust gas turbine. For starting the plant and for assistance to the gas turbine there is coupled with the compressor also a motor, current for which is taken from a Leonard-group. Automatic adjustment is provided for the feed-water, the fuel and the combustion air.

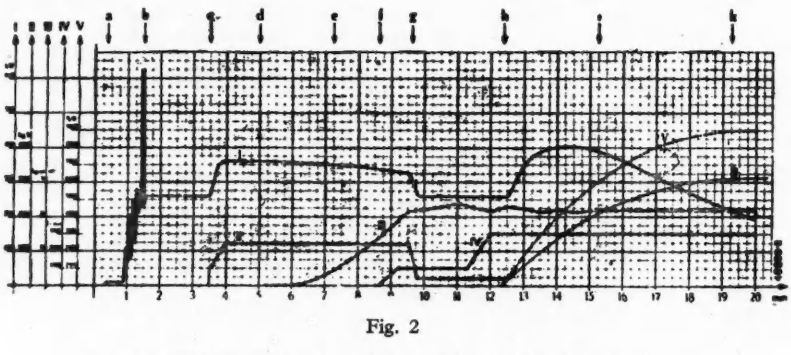


Fig. 2

Starting Diagram for the complete plant (results of tests) :—

(I) Auxiliary drives kW.
(II) Fuel consumption kg./h.
(III) Boiler pressure Kg./cm.² gauge.
(IV) Turbine speed r.p.m.
(V) Generator output kW.
(a) Diesel set in service.
(b) All auxiliaries in service.
(c) Ignition of boiler.
(d) Evaporation begins.
(e) Main steam valve opened.
(f) Steam turbine starting.
(g) Velox pressure regulator intervenes.
(h) Generator connected in parallel.
(i) Power station taking rated 6,000 kW.
(k) Power station taking full 9,000 kW. load.

The steam turbine is of the single-cylinder type with impulse and reaction blading. There are four nozzle valves, corresponding to the big overload of 9,000 kW. Up to 2,000 kW, one valve, up to 4,000 kW two valves, up to 6,000 kW three valves, and up to 9,000 kW all four valves have to be opened. The fuel consumption of the plant is 3.2 t/h of oil (Masut) of 9,800 kCal. per hour at full load.

A Diesel engine driving a three-phase generator of 400 kW, 600 r.p.m., 380 V is provided to feed the auxiliary motors of the power station and the Leonard-group mentioned before, should the station become entirely cut off from the supply system. As soon as the plant is started, this generator can be paralleled with the turbine, so that the maximum output can be raised from 9,000 kW to 9,400 kW, and may rise to 10,500 kW, when cosρ is high.

The normal voltage of the generator is 6,400 V. The circuit breakers are of the air blast high-speed type. Auxiliary services are supplied through a transformer bank of 600 kVA, 6,400/380 V.

The total costs of the plant amount to 1.6 million frcs. Of this sum 0.4 million frcs. were building costs.

Starting the plant.

Great importance was attached to simplicity of operation and quick starting. Programme of starting is shown in Fig. 2, the designations given thereon being experimental ones taken from the finished plant. Entire settling to work from the cold state can be carried out easily in 15 minutes. The arrangement made is such, that a chief machinist and an assistant suffice for starting the plant, and with this in view, the devices for running, supervision and attendance of the steam generator and the electrical plant are concentrated on the desk of the switch-board as far as possible.

Service results.

Effect. Output Kw ..	9216	6020	3856
Fuel Consumption kg/KWh referred to $H_u = 9800$ kCal/kg	0.3441	0.3468	0.3628
Overall Efficiency of plant %	25.50	25.30	24.19
Efficiency of Velox Generator %	93.4	93.3	92.7
Steam Consumption of Turbine kg/KWh ..	4.37	4.37	4.5

PRESSURE CONDENSERS

By C. DE LANGE. (From *Philips' Technical Review*, Vol. 4, No. 9, Sept., 1939, pp. 254-9).

AN increase of the reactive power $W = V^2\omega C$ which a condenser of capacity C can absorb, may be obtained with a given dielectric constant by raising the permissible field-strength in the dielectric. In paper-insulated condensers working in an alternating-voltage system, an increase of the normal field-strength of about 10 volts per μ can be obtained by placing the whole condenser under pressure.

It is essential to keep the field-strength at a safe low value, so that no ionisation may start in the unavoidable cavities of the dielectric containing gas or moisture.

Effect of pressure.

Disruptive voltage in a homogeneous field is determined by the product p.h of pressure p and thickness h of the gas inclusion (thickness of cavity). Relationship is represented by the Paschen-curve (Fig. 1). The curve has a minimum at which $V_d = V_J$; for air $V_J \backsim 45$ V. For a voltage above V_J breakdown may take place at any pressure between p_1 and p_2. This breakdown may be avoided by reducing p below p_2, or by making it greater then p_1. The first method is not feasible in practice, as it is difficult to insure that gas inclusions in the dielectric may not cause an unexpected raise of pressure. The second method has, therefore, been adopted for practical use.

Determination of the required pressure.

The pressure applied must be made so high that for every cavity h up to the thickness d

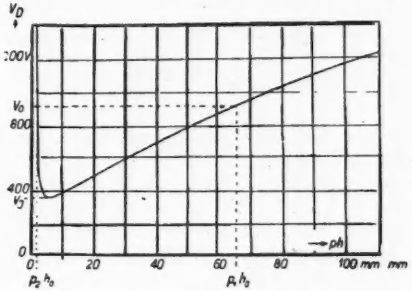


Fig. 1. Paschen Curve.

of the dielectric the disruptive voltage V_D will be greater than the voltage impressed on the cavity. Potential distribution can be calculated from Fig. 2. The two parts of the dielectric with thickness (d-h) and h may be regarded as two condensers with the dielectric ε_p and ε. For the gas inclusion $\varepsilon=1$. Since the same displacement current must flow through both condensers, there is

$$(V-V_h)\frac{\varepsilon_p}{d-h} = V_h \frac{1}{h}; \text{ hence}$$

$$V_h/V = \frac{\varepsilon_p \cdot h/d}{1+(\varepsilon_p-1)\,h/d}.$$

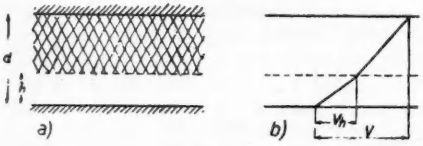


Fig. 2

In Fig. 3 V_h/V is plotted as a function of h/d. If concrete values for a practical case are taken for the parameters V and d, a curve representing V_h as a function of h can be derived from Fig. 3 by altering the scales. This curve can be combined with the Paschen-curve (Fig. 1), and for every thickness of cavity h the minimum value of p.h can be found, for which the disruptive voltage V_D is greater than the impressed voltage V_h. The required pressure p_1 then follows from h and the values of p.h thus found.

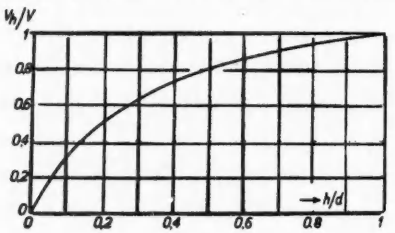


Fig. 3

In Fig. 4 the value of p_1 found in this way is plotted as a function of h for $d=30\mu$ and for different values of V (crest value of alternating voltage). Each of the curves passes through a maximum, the minimum pressure to be applied in the special case. For instance, for V=800 V, $d=30\mu$ the minimum pressure is p_{lm}=2,520 mm. Hg or 3.45 atm. If the pressure applied is greater than 3.5 atm. neither ionisation nor breakdown can occur in any cavity, which might be present in the dielectric. Curves can

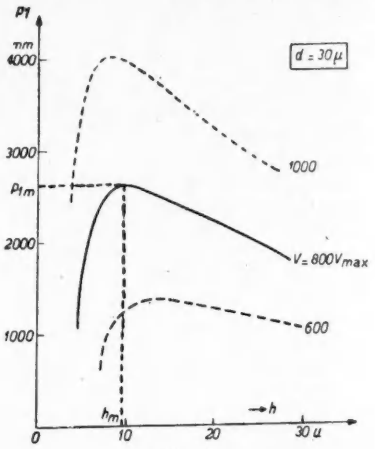


Fig. 4

be drawn (Fig. 5) which show which pressure must be applied to allow a condenser reel to sustain safely the impressed voltage V.

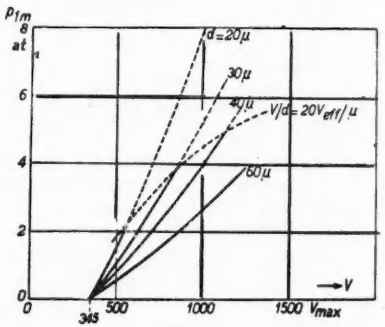


Fig 5

The parts shown in broken lines do not enter into practical consideration, as here the field strength of $20V_{eff.}/\mu$ (see below) is exceeded.

In order to assure the pressure in any cavity of the dielectric in spite of the viscosity of the oil in which the condenser reel is immerged, a gas, such as nitrogen, is dissolved in the liquid. Should the pressure fall in a cavity owing to delay in the oil-flow through the fibrous

channels of the paper, nitrogen is immediately liberated in the cavity, which it fills temporarily, becoming dissolved again as oil flows back into the cavity. Nevertheless, it is essential to make the pressure applied much greater than the value derived theoretically. Limit of the voltage applied is the dielectric strength of the oil, in which the condenser reel is immerged. It has been found, that at a pressure between 8 and 15 atm, a permanent field-strength of 20 V/μ may be applied. This result signifies that, by application of pressure, the voltage impressed on a condenser reel can be doubled, so that a quarter of the number of reels are required to obtain the same capacity than when no pressure is applied. In practice, a portion of this improvement may be reserved for increasing the safety factor.

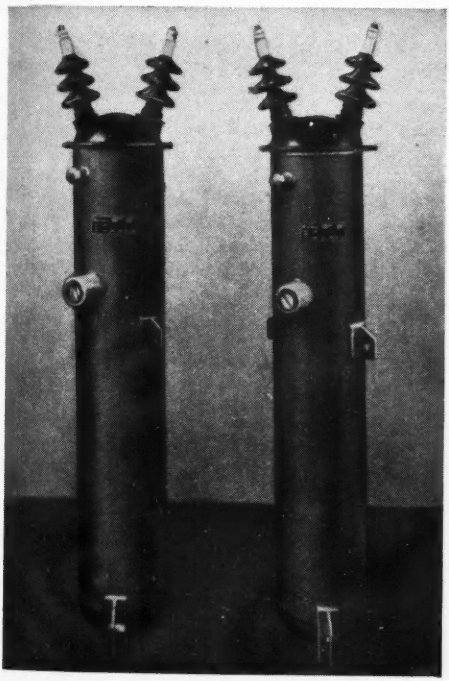


Fig. 6.

Pressure condenser for 50 kVA, 10,000 V. A manometer is inserted at half the height of the condenser. Initial pressure about 20 atm. Just above the pressure gauge is the pressure release, which is protected on the outside by a nut.

Construction of Pressure Condensers.

In the Philips Pressure Condensers (Fig. 6) the space above the oil filling is filled with compressed nitrogen. This method provides for the requisite solution of nitrogen in the oil. The tank is a seamless steel tube, to which a base and a cap are welded. Gas-tightness of all parts must satisfy severe specifications. Pressure must be obtained above a minimum value of 8 atm over a period of three years. A condenser becomes equivalent to new if nitrogen is recharged at regular intervals. Filling and recharging are done through a rubber valve, similar to that used on motor car tyres. As a valve of this type is unsuitable as a seal, a reliable seal is obtained with a cap placed over the valve and soldered after charging the condenser with gas.

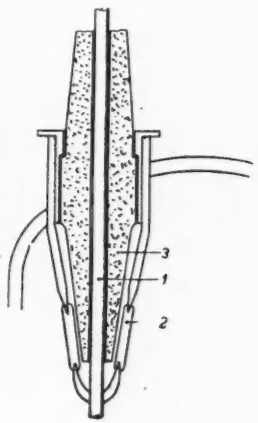
Maximum increase of pressure due to rise of temperature in the tank of 40° C, which may occur, has been found not greater than 20% the tank can withstand in perfect safety. A thin copper diaphragm is soldered in the side of the tube close to the cap, to provide release at excessive high pressures, which may be created, when electric damages in the condenser occur, for example, by atmospheric surges.

The electric glands are shown in Fig. 7. The condensers are suitable for open air mounting.

Pressure condensers are made for power ratings from 10 to 100 kVA, and for effective voltages from 380 to 10,000 volts.

Fig. 7.

Section of an electric gland. The electrode stem 1 is fused into a glass insulator 2, with a chrome steel liner, the glass insulator in its turn being welded into the cap of the condensor tube with a similar liner. On the outside, the electrode stem is supported by a ceramic insulator 3.



AUTOMATIC RECORDING OF THE ANGLE OF DEFLECTION OF CONTROL SURFACES

By KAREL PECIVA, Military Aircraft Factory, Letnany. (From *Strojnicky Obzor*, Vol. 19, No. 3, 1939, pp. 47-48).

VERBAL reports of test pilots are nowadays confirmed or replaced by automatic recording devices, whenever this is possible. With the aid of these records, all causes influencing the stability of the aeroplanes can be studied. The reconstruction of flights based on accurate records is of special value, particularly when they are to be compared with tests and measurements in aerodynamic tunnels.

The Czechslovak Military Aircraft Factory in co-operation with the PREMA instrument manufacturing firm, constructed an apparatus with remote controlled electric starter described below.

The instrument is mounted in the cylindrical framework B, which also supports the shaft C. The shaft C carries an adjustable lever A. Inside the framework B, a pulley D is attached to the shaft C. The motion of D is transmitted to a small pulley E by means of a belt. Another pulley is attached to the shaft of the pulley E, and the spring belt of this moves the slider F. The pulley, together with

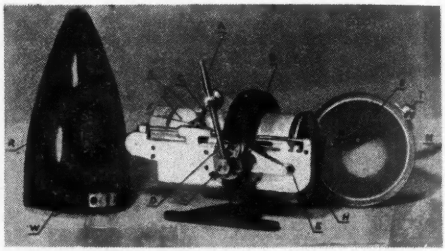


Fig. 2

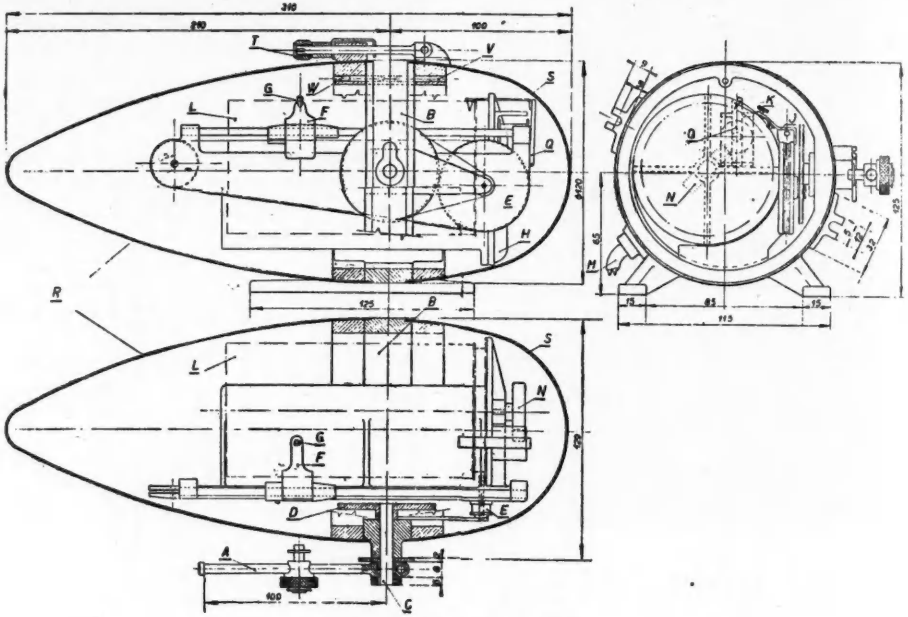


Fig. 1. (Measures in mm.)

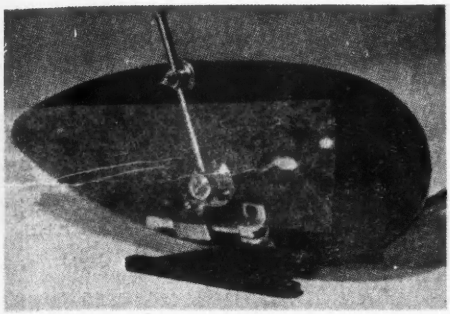


Fig. 3

the belt and spring,are situated in the casing H, which also supports the rail of the slider F. The latter carries an arm J, the end of which forms the recording pin G. The pressure of the pin G is adjustable by means of a screw K.

A suitable set of levers connects the lever A with the aeroplane control surface (Fig. 4), the movements of the latter are thus registered on the drum L. The maximum amplitude of the lever A is 60° corresponding to a movement of G of 120 mm.

Recording takes place on a suitable graph paper attached to the drum L (Fig. 5); the abcisse correspond to the time in seconds, and the ordinates to the angle of deflection. The drum is driven by a clock mechanism from the inside of the drum. This mechanism can be started by the pilot, and is energised from a D.C. current of 14.5 volts.

The mechanism is usually started by a switch fixed on to the instrument panel. The cable M of the starter can be seen in Fig. 2. N is a key to wind up the clock mechanism,

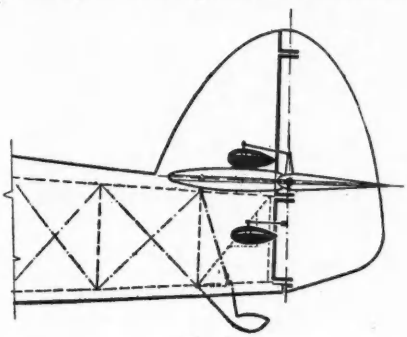


Fig. 4

the electric magnet with Q registers the time intervals. The two parts S and R of the streamlined cover can be fixed together by means of V, W and T as can be seen from the illustration. The total weight of the instrument (including the weight of the cable) is 2.35 kg.

Fig. 5 shows graphically the angles of deflection of the elevator and the rudder while spinning. Three trials were made:

I. Three left turns.
II. Three and a half left turns.
III. Four and a half left turns.

The first spin reads as follows:

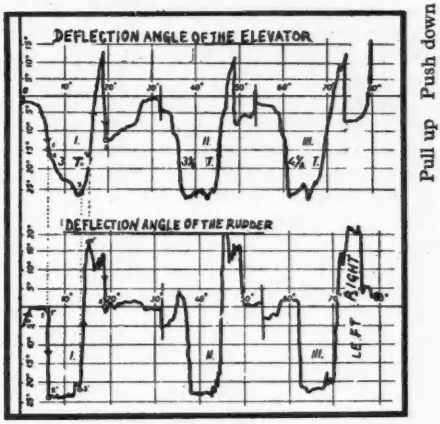


Fig. 5

After starting the instrument, the pilot pulled the elevator at minimum aircraft speed to point 1. At the same time the rudder was pushed into its extreme position according to point 2'. The elevator deflection was increased to point 3, when the aircraft started to spin. In order to right the aeroplane, the pilot pushed the rudder bar in the opposite sense, the angle of the rudder being registered at point 4', and the elevator angle being decreased accordingly to point 4. After completing the third turn, the rudder was brought to the neutral position at point 5', and the elevator (still decreasing the angle of deflection shown in point 4, and reaching an angle of 13° in the opposite sense) was pulled to position 5.

A complete picture of the behaviour of the plane during spinning was thus obtained, by measuring in addition the angular acceleration of the plane and the forces on the control columns.

FLUID COUPLINGS IMPROVE ENGINE PERFORMANCE

By N. L. ALISON, R. G. OLSON and R. NELDEN. (From *Machine Design*, Vol. 12, No. 8, August, 1940, pp. 45-47).

PREVENTING the transmission of torsional vibrations and protecting engine and gears from sudden shock loads, the hydraulic coupling was first used aboard ship, a section through a coupling and pinion of a typical marine gear being shown in Fig. 1. A pump delivers oil from the sump tank into the working circuit of the coupling. Variable speed is provided by regulating the quantity of oil, and declutching is attained by shutting off or draining oil. In traction and industrial applications, the units are self-contained, and do not utilize an external tank or pump.

Exhaustive tests show that the efficiency of the marine hydraulic coupling always equals 100 minus the slip in per cent, and that the torque input is equal to the torque output for all conditions of speed and filling. It is customary in marine service to use couplings having a slip of between 2½% and 3% in order to keep down the overall diameter. Since the power required by the oil-circulating pump amounts to approximately 1¼ of 1% of the engine horse-power the overall efficiency of the coupling will be about 97%. The windage losses are negligible.

An important characteristic is that the slip remains constant for all engine speeds, due to the fact that the power-transmitting capacity of the coupling and the power required by the propeller both vary as the cube of the speed.

Although hydraulic couplings are used extensively for the variable speed drive of fans, turboblowers, pumps, and machines requiring constant torque, the characteristics of the coupling when used for variable-speed propeller drive are perhaps not so well known. Curve A in Fig. 2 indicates the power required by a propeller in percentage of full power over a range from 100% down to zero speed, assuming that the load varies as a cube function of the speed. Curve B shows the power input to the hydraulic coupling based on the assumption that the engine is running at maximum

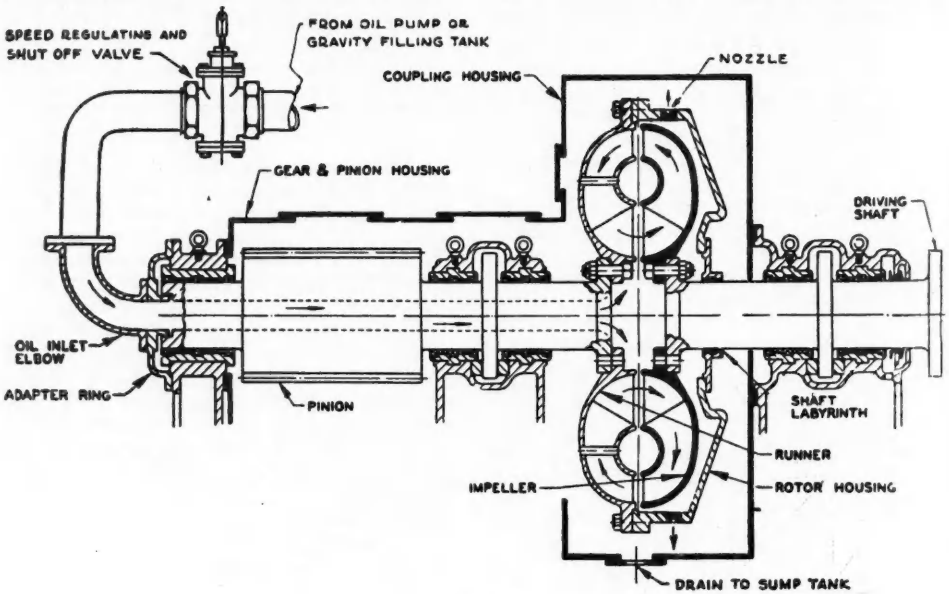


Fig. 1

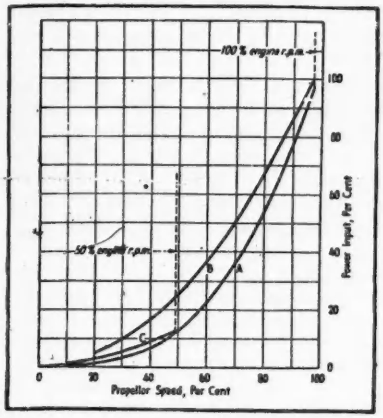


Fig. 2

Variable speed performance curve, A being horse power at propeller, B the coupling input horse power at full engine speed, C the input horsepower at half speed.

speed, and the regulation of propeller speed is obtained entirely by varying the quantity of oil in the coupling circuit. It will be seen that the power input drops off rapidly and that the difference between curve A and curve B, representing the loss of power in the hydraulic coupling, varies from a maximum of 16% of full power at 65% speed to approximately 5% at 20% speed. Curve C shows the power input to the hydraulic coupling assuming that the engine speed is reduced to 50% of maximum and that the propeller speed is reduced down to 10% of maximum by means of the hydraulic coupling.

The axial thrust of the coupling when full of oil acts in the outward direction tending to separate the two members, while with the coupling only partially filled the thrust acts in the opposite direction. Therefore, it is necessary to provide bearings to take the thrust in both directions, and in marine applications this is usually handled by thrust collars on the driving and driven shafts.

In connection with declutching, various types of quick-emptying valves are utilized. Constant-leak nozzles are used on the coupling in Fig. 1, where rapid declutching is not required. This nozzle requires two to five minutes to empty the coupling completely. A ring-type dumping valve permitting declutching in from three to five seconds is sometimes used with marine couplings, while recent development is a piston valve type. The traction coupling differs from the marine type in that in it no provision is made for completely disconnecting the driving from the driven member. It is a self-contained unit, operating with fixed quantity of oil, and does not require an external tank or pump.

Characteristics of the traction coupling, used as a power take-off with an internal combustion engine are shown in Fig. 3. Curve C-D shows the slip of the coupling from 100% to 40% engine speed, when delivering maximum engine torque to the driven machine, and it will be seen that this slip increases from 2½% at point D to 100% at point C. This represents full throttle condition. Curve A-B represents the torque output from the coupling with the runner stalled and the engine operating at reduced speed. Ability of the coupling to prevent engine stalling is shown by curve C-D, indicating how the effect of overload is to pull down the engine speed until point C is reached, when the slip rises to 100% and the output shaft stalls.

In the traction coupling a ring-shaped baffle is attached to the coupling at the inner profile diameter, and serves to impede the oil circulation when working at high slip or when stalled, thus reducing the drag torque. The baffle has no effect on the slip at normal load and speed, and by varying its diameter the point of coupling stall when delivering full torque can be changed to suit the operating characteristics of the engine.

The reservoir on the back of the runner serves as an expansion chamber; consequently, there is no possibility of building up excessive pressure due to overheating of the oil in case the coupling is allowed to remain stalled for long periods with the engine developing full torque.

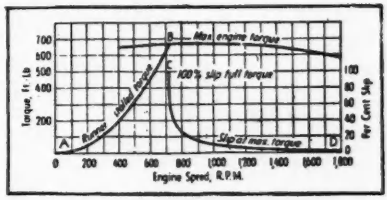


Fig. 3

SEGMENTAL BEARING DESIGN PROMOTES STABILITY

By HANS ERNST. (From *Machine Design*, Vol. 12, No. 8, August, 1940, pp. 51-52).

SPINDLE flutter or change in position under load must be reduced to a minimum when highly accurate operation is necessary. For an ideal precision spindle assembly the following characteristics would be necessary:

(1). To prevent metallic contact an uninterrupted fluid film must be maintained between the spindle and the bearing.

(2). Movement of the axis under changing forces must be as slight as possible.

(3). The bearing must be able to support loads which might vary in direction through a wide angle.

(4). Frictional losses in the bearing should remain practically constant regardless of fluctuations in the load.

(5). The bearing should resist wear as much as possible and not require adjustment to meet varying conditions.

In an ordinary bearing a single wedge-shaped oil film is developed which converges in the direction of rotation. Since the position and shape of the wedge varies with any change in direction or magnitude of the load on the journal, an unstable condition exists which causes displacement of the axis of the journal. This is accentuated by the fact that where the film diverges in the direction of the journal movement, as it must, a sub-atmospheric pressure may develop. If air is drawn in by this action, additional instability will result.

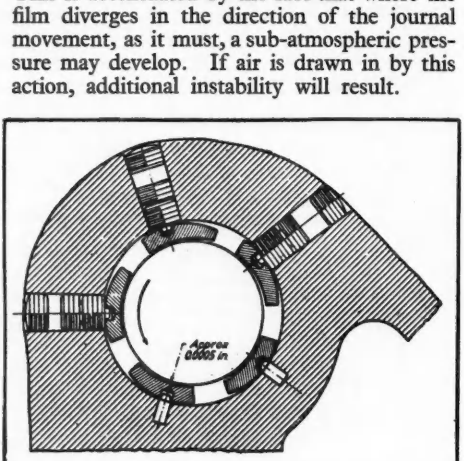


Fig. 1

It is obvious that if the oil film is interrupted, thinner films will develop, and theoretically the stability and rigidity of the spindle will be increased. Breaking up the film by grooves and scrapers has been employed to obtain these thinner films. However, because this decreases the load-carrying capacity of the film it makes for less safety against seizure and short bearing life.

Pressures generated by the wedge-shaped film can be made to promote spindle stability if three or more wedges, equally spaced around the spindle, are formed. The high pressures generated act radially to hold the journal centred and away from the bearing. This principle is

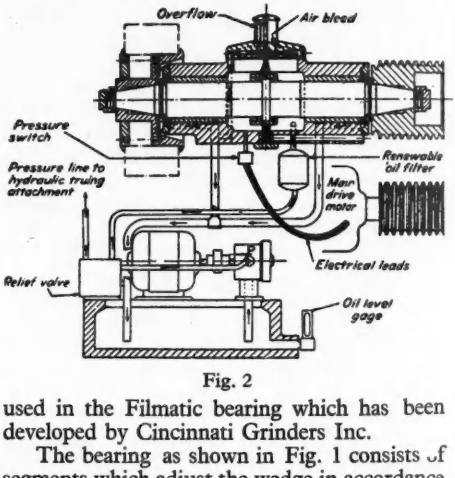


Fig. 2

used in the Filmatic bearing which has been developed by Cincinnati Grinders Inc.

The bearing as shown in Fig. 1 consists of segments which adjust the wedge in accordance with the load placed upon the journal. Acting together, the segments lock the spindle in its correct central location. Yet an uninterrupted film of oil is maintained between each jaw and and the journal, so that spindle rigidity is secured without metal-to-metal contact. The coefficient of friction is practically the same as with anti-friction bearings.

While early models showed improved performance over other bearings there was transverse movement of the spindle to the extent of about 50 microinches. This movement was due to two causes: entrained air and momentary

fluctuations in the oil supply. This was corrected by providing an air bleeder system and by maintaining the oil supply in the bearing chamber at higher than atmospheric pressure. Bearing and spindle assembly are shown in Fig. 2. Oil supply is provided by a motor driven pump, a relief valve maintains the oil pressure in the chamber at the desired point, while air which becomes entrained, is liberated through an air bleeder shown above the central chamber.

To prevent danger of damage from starting the spindle before adequate pressure exists in the oil chamber, the spindle motor is started through a pressure switch, which acts through a relay. Oscillograms of this bearing design show no perceptible flutter in either plane of movement. With machines equipped with the new type of bearing it is possible to use wheels two grades softer than would be otherwise possible, since " hammering " of the grinding wheel due to loose spindle is avoided.

THE PITCAIRN WHIRL WING

By AGNEW W. LARSEN. (From *Aviation*, Vol. 39, No. 9, September, 1940).

THE Pitcairn " Whirl Wing " autogyro represents the completion of a successful development for the purposes of all civil, commercial and military aviation.

The aim was set at developing an autogyro which had safe flying and slow landing characteristic including the direct or " jump " take-off feature.

The placing of the engine behind the pilot's seat is of major importance; the advantages are as follows:

For both pilot and passenger better visibility is achieved. The power to drive the rotor starting shaft can be taken from the front of the engine, permitting unlimited use of the available horse-power for bringing the rotor up to speed. The forced-draft cooling of the engine can be controlled under all conditions of flight.

As the autogyro can and does maintain flight at low speeds, the engine on previous types where cooling depended on the air speed, were frequently overheated. In the " Whirl Wing," the use of a drive shaft from engine to transmission required the installation of a fly wheel to remove any tendency towards torsional vibration in the shaft. This fly wheel was designed with an integral Sirroc fan around its perimeter for forcing the air through the cooling system. It also incorporates a ring gear, which makes possible the use of a standard automotive type electric starter.

In this cooling system, air is drawn in under pressure from the nose of the aircraft. The air is carried through a duct which passes under the floor and seats to the fan housing. There is a small radiator in this duct which cools the oil for the transmission unit. After passing through the fly wheel fan, the air is guided by means of carefully designed baffle plates. Another oil cooler is located in the cold air stream for cooling the engine oil. After the air has passed the engine, it goes into the rear of the fuselage, the outlets being in points of negative pressure.

A brief explanation of the jump take-off, which is the main feature of this type, may be given. The rotor which furnishes all the lift has three blades that are threaded in the rotor hub. A short lever arm is fastened to each rotor-spar just outside of the threaded connection, and small hydraulic cylinders are located so that the pistons they contain bear against the smaller lever arms on the spars. When hydraulic pressure is applied to these three cylinders, the pistons are forced out against the lever arms, which turn the threaded blade connection into the rotor hub. Stops are provided so that with the pressure applied the screwed-in blade spar connections hold all rotor blades at the flat or zero lift position. The rotor can be accelerated to 300 r.p.m. with the aircraft standing still on the ground. Relieving the pressure in these cylinders permits the blades immediately to " unscrew " for normal flight pitch. Since normal flight rotation of the rotor is only 180 r.p.m., the kinetic energy stored in the overspeeded rotor is then converted into lift.

As in previous autogyros each rotor blade is attached to the hub through two hinges, namely, a flapping hinge which permits a limited up and down movement of the blade, and a drag hinge which allows limited angular movement in the plane of rotation. The flapping hinges are at 60° to the rotor blade axes,

BUILDING-UP AND HARD-SURFACING

By L. AMES. (From *Iron and Steel Engineer*, Vol. XVII, September, 1940, No. IX, pp.64-65).

IN recent years the steel industry has made every effort to cut operating costs, while maintaining production schedules and turning out quality products. Substantial economies have been realised by building-up and hard-facing worn parts. Three major processes are employed for this important phase of welding: oxyacetylene, metallic arc and carbon arc. The oxyacetylene process is generally used for cast iron welding, bronze welding and non-ferrous metal welding. With the torch, the operator has accurate control of the rate of metal deposit, thickness and smoothness of the overlay. The metallic arc process is the one most widely employed in steel plants. The speed of metal deposit, economy of operation, wide selection of electrode analysis and flexibility are all in its favour. It permits welding in confined areas and on heavy machine sections. The carbon arc is used to a lesser degree, but is preferred for filling sand holes in steel castings, building-up badly worn cast iron wobbler ends, copper welding of heavy sections, and similar applications.

A good rule to follow in building-up is to use a welding rod of an analysis similar to that of the base metal. It is now possible to obtain suitable rod material to meet almost any requirement. The conditions under which the part works should be thoroughly studied before a build-up material is selected.

Reclaiming worn piston heads by bronze welding, building-up worn or broken gear teeth, reclaiming of cast iron, steel and bronze mill guides, by building-up or hard-facing, building-up and hard-facing worn shafts and reclaiming worn wobblers, rolls and roll-necks are good examples of steel mill applications of the welding processes. In many plants, track maintenance costs and derailments have been materially reduced by building-up rail ends, frogs and switch points in yard track. This welding is usually done with the oxyacetylene torch. In rail welding, a welding rod with a deposit that will resist impact and abrasion and which will not spall is selected. Frogs can be welded in place, but it is preferable to perform this operation in the shop. Manganese frogs are built-up with metallic arc process.

Both building-up and hard-facing are playing an increasingly important part in reducing costs in the steel industry. In the face of the present emergency, with the attendant difficulty of procuring new replacement parts, the value of reclaiming and prolonging the life of worn equipment cannot be over-emphasized.

BOOKS AND CATALOGUES RECEIVED

The Corrosion of Iron and Steel.

A general account of the work of the Corrosion Committee of the Iron and Steel Institute and The British Iron and Steel Federation. By J. C. Hudson, with an Introduction by Dr. W. H. Hatfield, F.R.S. and Dr. T. Swinden. London: Chapman & Hall Ltd. Price 18s. net.

Non Ferrous Foundry Practice.

By J. Laing and R. T. Rolfe. London: Chapman & Hall Ltd. Price 21s. net.

Records and Research in Engineering and Industrial Science.

A Guide to the Production, Extraction, Integrating, Storekeeping, Circulation and Translation of Technical Knowledge. London: Chapman & Hall Ltd. Price 15s. net.

Tools for Aircraft Production.

A new Catalogue of the Consolidated Pneumatic Tool Company Ltd., 232, Dawes Road, London, S.W.6., covering the whole range of Pneumatic Universal Electric and high frequency electric tools for aircraft construction. Supplied to readers of THE ENGINEERS' DIGEST, upon application, free of charge.